Raytec White-Paper

# LED vs Fluorescent

A look ahead to the fluorescent lamp ban.

# Why You Should Upgrade Your Linear Lighting System

This white paper was first launched in 2015 when the use of Ex-rated LED luminaires was still relatively new to applications designated as hazardous areas. Since 2015, the performance of LED luminaires has continually improved as the technology develops. While the proportion of LED luminaires being installed in hazardous locations has also grown significantly, a large number of fluorescent fittings are still being used across sites today.

With the sale of T5 and T8 fluorescent tubes due to be banned from August 2023, the need to find alternative solutions to traditional lighting technology is more pressing than ever.

To see just how much LED technology has improved, Raytec has decided to revisit its study comparing fluorescent fittings with more modern LED Linear luminaires.

# LED vs Fluorescent: An Introduction

Even today, fluorescent lighting is used extensively across the world in a wide range of applications. Historically one of the most widely deployed forms of lighting technology (in part due to the increased efficiency compared to incandescent lamps), many hazardous area sites still rely on the use of fluorescent luminaires for illumination.

If you work closely with lighting, you may be aware of some of the issues which can occur with fluorescent technology. For many applications using fluorescent luminaires, this is easily highlighted by a quick look around the site - you will likely see numerous fittings which are no longer working, or if they are all still running, frequent maintenance will be required to ensure they are operating correctly.

LED linear luminaires provide a solution to many of the problems which exist with traditional fluorescent fittings - if you haven't already then you should be considering upgrading your site to LED. In this white paper, we will tackle some of the key issues when comparing LED linear fittings to fluorescent fittings, including;

1. Performance
2. High output LED variants and the use of optics
3. Suitability to harsh environments
4. Maintenance
5. Other considerations (disposal, emergency performance and quality of light)

# 1. Performance

Before we look at a more in-depth comparison, it is useful to highlight some of the expected advantages of LED luminaires;

- Longer Life – fluorescent luminaires are more prone to failure compared to LEDs which have a near 0% failure rate.
- Lower maintenance with no need for relamping – the long-life of LEDs means that, unlike fluorescent fittings, there is no requirement for ongoing lamp changes over the course of an LED luminaire's lifetime.
- More consistent light output – over time a fluorescent luminaire will lose almost 40% of its initial lumens, compared to an LED fitting which will lose just a fraction of this figure.
- Better performance under higher temperatures – unlike fluorescent luminaires, LED equivalents are largely unaffected by extreme temperatures, hot or cold.

While these are areas we will look at in more depth throughout the white paper, they provide a brief overview of the differences between fluorescent and LED technology, as well as an indication of the results we can expect to see when comparing data.

End of life fluorescent tube showing signs of degradation

*Pro-Tip Unlike a fluorescent fitting, the 'failure' of an LED equivalent does not mean that the LEDs will stop providing light output altogether, but instead the term is used to describe when 50% of the LEDs in a fitting drop to 70% of their original lumen output.*

## Light Output Comparison

Whenever a new luminaire is replacing an existing fluorescent, it must always provide an equivalent or superior light output – after all, what would be the point in 'upgrading' to a new technology, only to see a decrease in output?

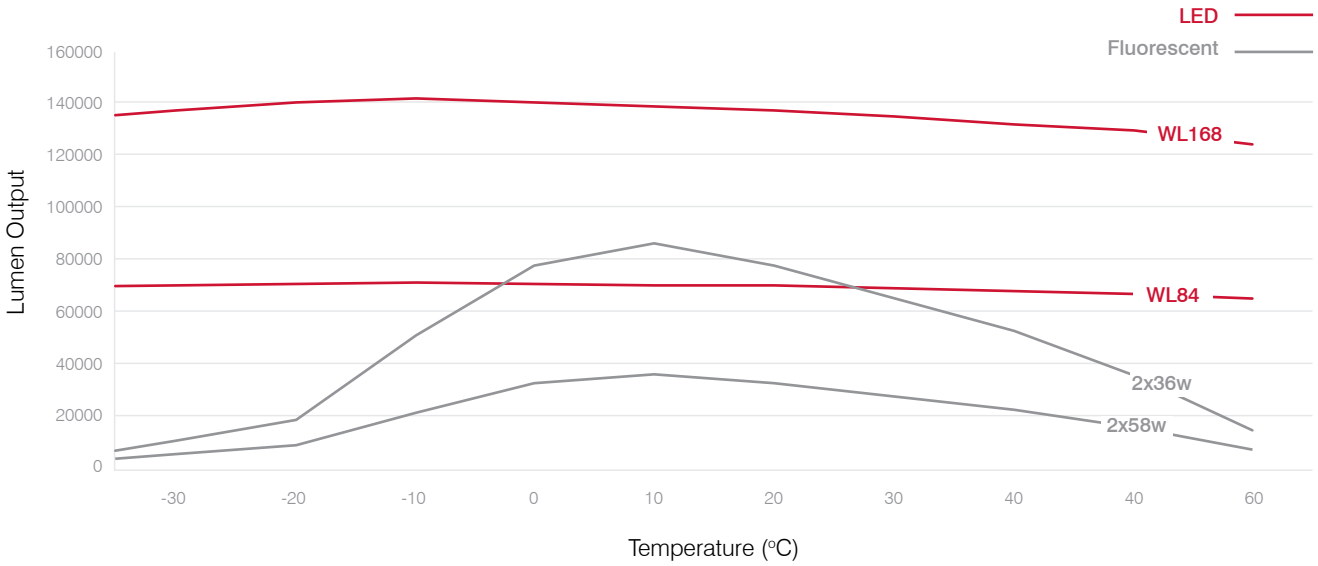
Using data produced by OSRAM, a manufacturer of both fluorescent T8 lamps and LEDs, we've been able to create a comparison which shows how the two types of technology perform over time. The data was compiled to represent a generic style of Zone 2 fluorescent, commonly known as 'boat fittings', usually manufactured with a GRP base and a polycarbonate cover. The LED technology is represented by Raytec's SPARTAN Zone 2 Linear luminaire. For retrofit applications, the SPARTAN WL84 would be used to replace a 2x18W fluorescent and the SPARTAN WL168 to replace a 2x36W fluorescent.

## Conditions of the data

- All data has been collected from OSRAM – both for the T8 tubes which are commonly used in traditional fluorescent luminaires, and for the LEDs which are used in SPARTAN products
- The data has been calculated based on an installation of 20 luminaires. This allows failure and degradation to be included in the results.
- The results are displayed using 2 variables; lumen output and ambient temperature. Lumen output is an indicator of the performance of a luminaire, while temperature has been selected given that it will frequently fluctuate between applications and directly affects the lumen output of a luminaire. The more consistent the lumen output and the less degradation that occurs over time, the better the overall performance of a luminaire

## Initial Performance

The first performance comparison will look at the output from each luminaire at the date of installation – the first time the luminaires are turned on.




Immediately, it's very clear from the higher position on the graph that the LED luminaires deliver significantly higher lumen output than an equivalent fluorescent fitting (WL84 vs 2x18W and WL168 vs 2x36W) - this is despite the lumen output figure quoted by the fluorescent fittings being similar to the LED alternative. The first thing to try and understand is why this difference is so vast when the claimed outputs are so similar.

The variance can be largely explained due to the inefficiency of fluorescent technology, which results in a large proportion of the output being lost. Let's look at an example using a 2x36W fluorescent;

- A typical 2x36W fluorescent has an efficiency of 68.3%, of which 93.2% is downward light (the other 6.8% is wasted).
- Using two tubes with an initial lumen output of 3,350 lm, the fitting will provide a total of 6,700 lm.
- Taking into account the efficiency and percentage of downward light allows us to calculate the usable downward lumens; 6,700 lm x 0.683 x 0.932 = 4,265 usable downward lumens

In contrast, the lumen figures quoted on SPARTAN Linear are 'delivered lumens' where any losses have already been included. The extent of these differences means that a WL84 LED luminaire (that normally matches up to a 2x18W fluorescent) provides a superior output to a much larger 2x36W fluorescent fitting, in all but the most optimum of conditions.

## Effects of Extreme Temperatures

An obvious difference when comparing the SPARTAN LED units with the fluorescent fittings is the difference in shape between the corresponding lines on the graph. The LED luminaires maintain a consistent light level (shown by the relatively straight line on the graph) despite the extreme temperatures at either end of the graph. In contrast, the performance of the fluorescent fluctuates significantly across different ambient temperatures (producing a curved line). This tells us that LED fittings are more suited to applications which are subject to extreme temperatures.

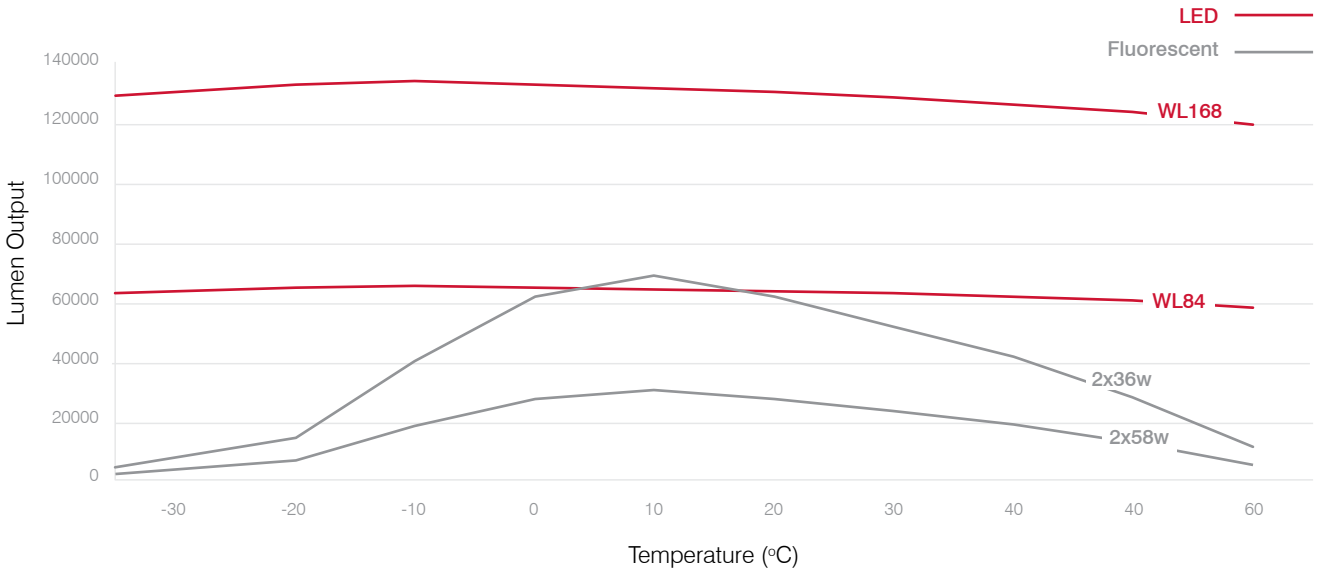
In terms of light output, we have already touched upon the feasibility of replacing a 2x36W fluorescent with a WL84 LED fitting; the extent of this is magnified in more extreme temperatures. Outside the 'optimum' operating temperatures (around -5°C to +25°C) the WL84 provides superior light output from the initial installation. By understanding the environmental conditions of an application and how a luminaire performs in its environment, a smart specification can get additional advantages from switching to LED. Fundamentally, in extreme temperatures a much smaller LED product can be utilised; this will not only reduce the initial unit price but will ultimately provide huge energy savings. For applications off-grid relying on the use of generators as the primary power source, this will also help to significantly reduce the overall consumption of lighting and free-up generator capacity.

A large offshore production platform may have over 2,000 fluorescent fittings installed and if a 2x36W (72W) fluorescent can be replaced by a 32W SPARTAN Linear WL84, it could mean a massive saving of over 80Kw/h. Even for smaller applications where there are fewer units installed, the saving is still significant.

The feasibility of replacing a 2x36W fluorescent with a WL84 LED fitting is something we will continue to explore throughout this paper and in the next series of graphs which looks at performance a number of months down the line and begins to consider the effect of degradation.

## Performance After 8,000 Hours

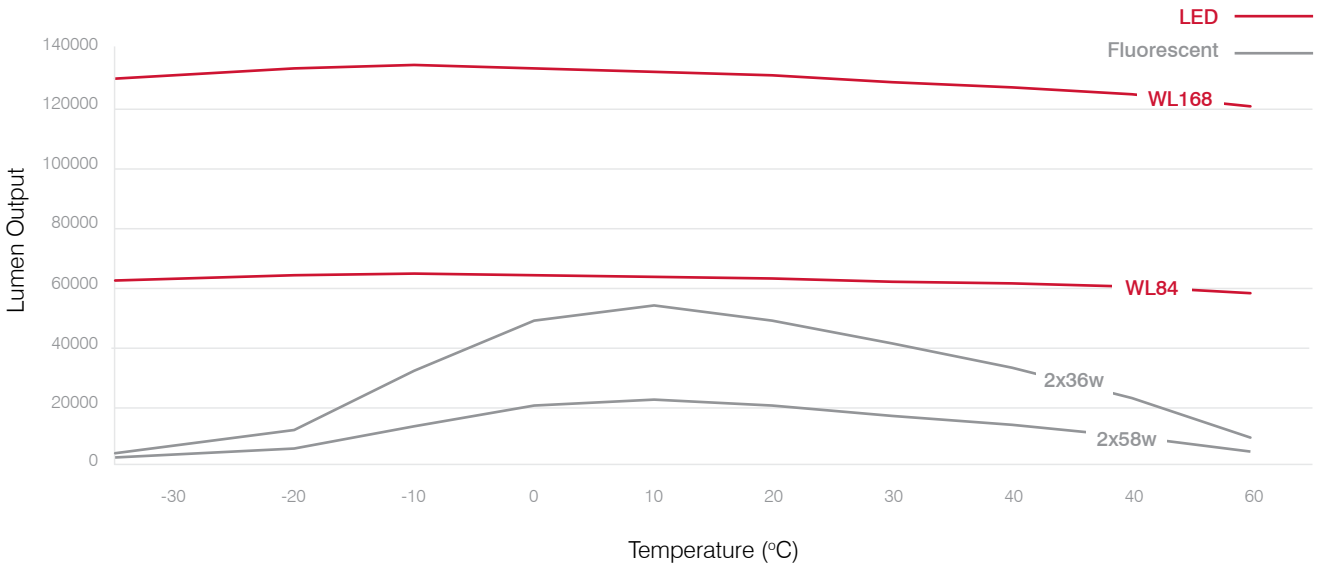
After looking at the differences in performance between brand new fittings, the next step is to consider the effect of time and how the fittings perform over the duration of their life. The first interval we'll look at is 8,000 hours, almost 1 year of constant operation.




After 8,000 hours there is already a significant degradation in the performance of the fluorescent fittings. The cause of this lumen depreciation is mainly due to the photochemical degradation of the phosphor coating and the glass tube.

In contrast, the LED SPARTAN has maintained an output almost identical to the first graph thanks to a near 0% failure rate and virtually zero degradation.

## Performance After 12,000 Hours




Fast forward around another 6 months of constant operation and the degradation of the fluorescent fittings has continued at a significant rate. Even in the most optimum of conditions the fluorescent fittings have lost 37% of the total lumen output across the installation, compared to the LED fittings which have seen just a 6% reduction. With the level of performance after 18 months, a WL84 LED unit now provides superior light output in all conditions over a 2x36W fluorescent.

Going beyond 18 months, the performance of the fluorescent fittings will continue to deteriorate to the point of rendering them close to useless in all but the most optimum of conditions. In contrast, the LED SPARTAN Linear has provided a consistent level of output and will continue to do so for 100,000+ hours.

## Summary of Data

The LED luminaires have outperformed the fluorescents from the moment of the initial installation and have shown a far greater consistency in their performance over an 18-month period thanks to the long life and consistent output of the LEDs. Although this relatively short-term performance advantage is significant, the real benefit comes from the future years of operation. SPARTAN LED Linear luminaires will provide a lifetime of 100,000+ maintenance-free hours in which time a fluorescent would require several maintenance interventions.

# 2. High Output LED Variants & Optics

Given the past popularity of fluorescent fittings and the vast numbers which have been installed, there is an ongoing demand for ‘retrofit’ LED products.

A retrofit LED luminaire should be easy to install in place of a fluorescent; this means using the same general dimensions, cable entries and fixing centres. This will allow the end-user to utilise the existing cable, glands and bracketry and reduce the cost of installation. For new installations however, these factors are less relevant and the end-user can focus should focus on specifying the most efficient and cost-effective solution.

## High Output LED Variants

The advancement in LED technology means luminaires are now available which offer significantly higher levels of performance than retrofit solutions designed as a like-for-like fluorescent replacement. The SPARTAN Linear luminaires that we used for comparison in section 1, are now available as High-Output variants which offer significantly improved performance.

**SPARTAN Linear WL84**

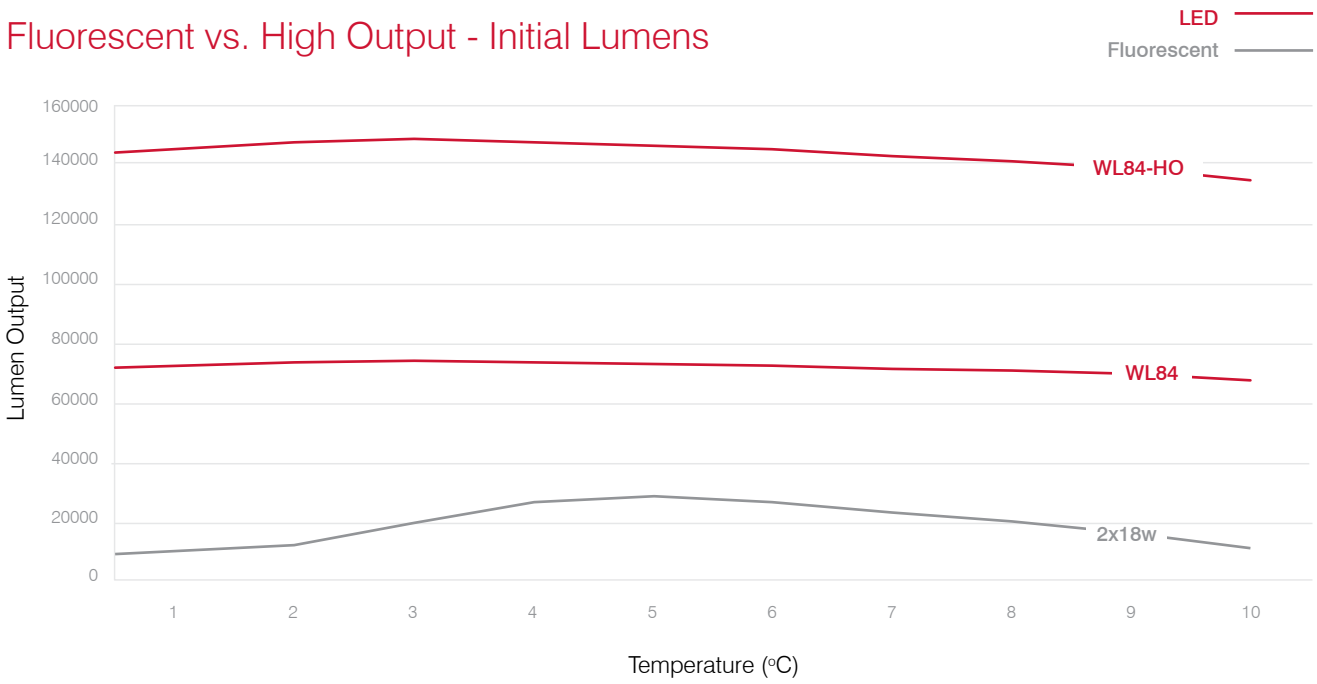
| | |
|---|---|
| Output | 3,524lm |
| Consumption | 32W |
| Primary Use | Designed as a retrofit solution for 2x18W fluorescent fittings |

**SPARTAN Linear WL84 High Output**

| | |
|---|---|
| Output | 7,048lm |
| Consumption | 48W |
| Primary Use | designed for new installations to provide maximum levels of performance and efficiency |

Using the same conditions that we set out in section 1 of the white paper, but now adding in the SPARTAN Linear High Output variants, we can see the extent of the performance upgrade compared to the standard WL84 LED luminaire, but even more significant when compared to traditional fluorescents .

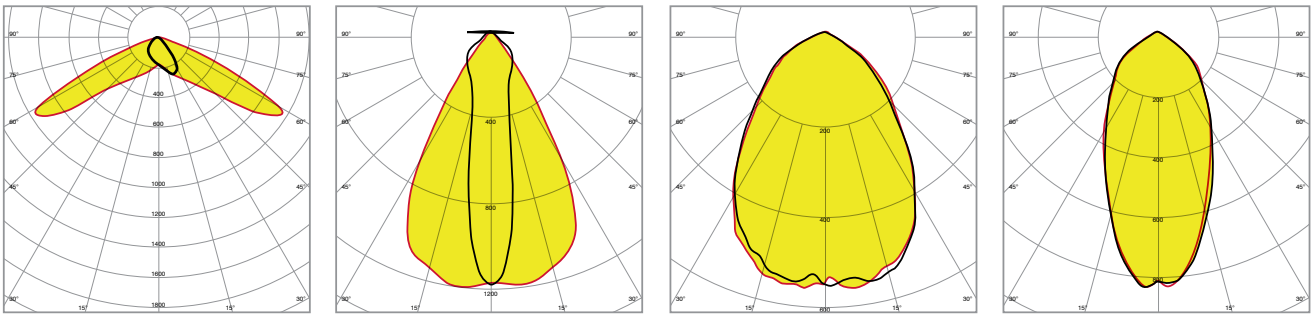
## Fluorescent vs. High Output - Initial Lumens



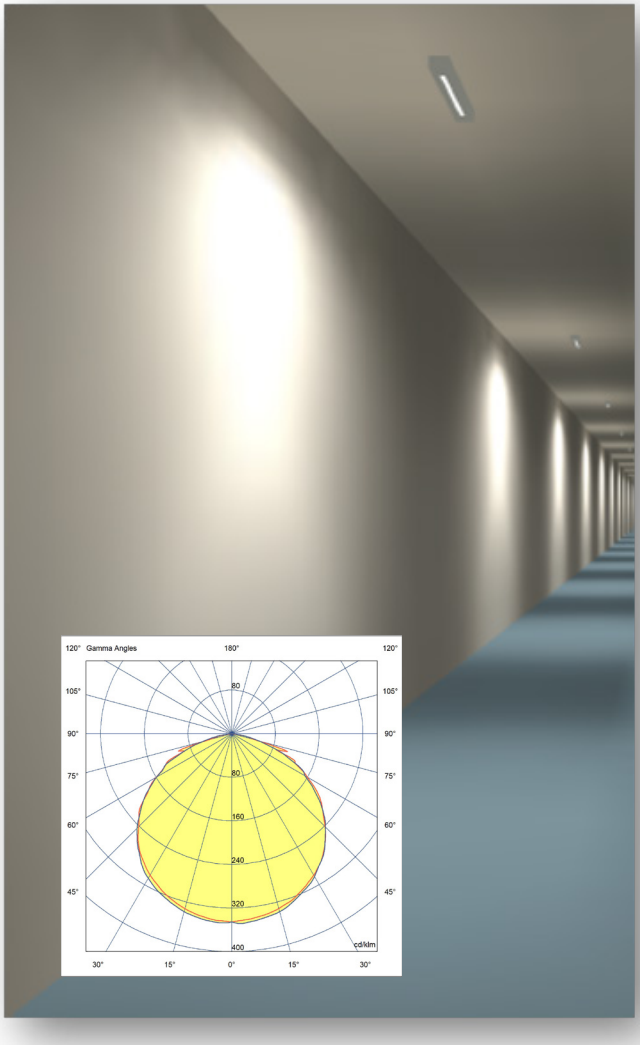

In short, the latest LED luminaires, such as the SPARTAN Linear WL84 and WL168 High Output represent a step change in how Linear fittings can be deployed. The extent of the performance jump means end-users can use a smaller, more efficient solution than before. It also means the Linear format can be deployed at increased mounting heats which provides a cost-effective alternative to a traditional bay solution.

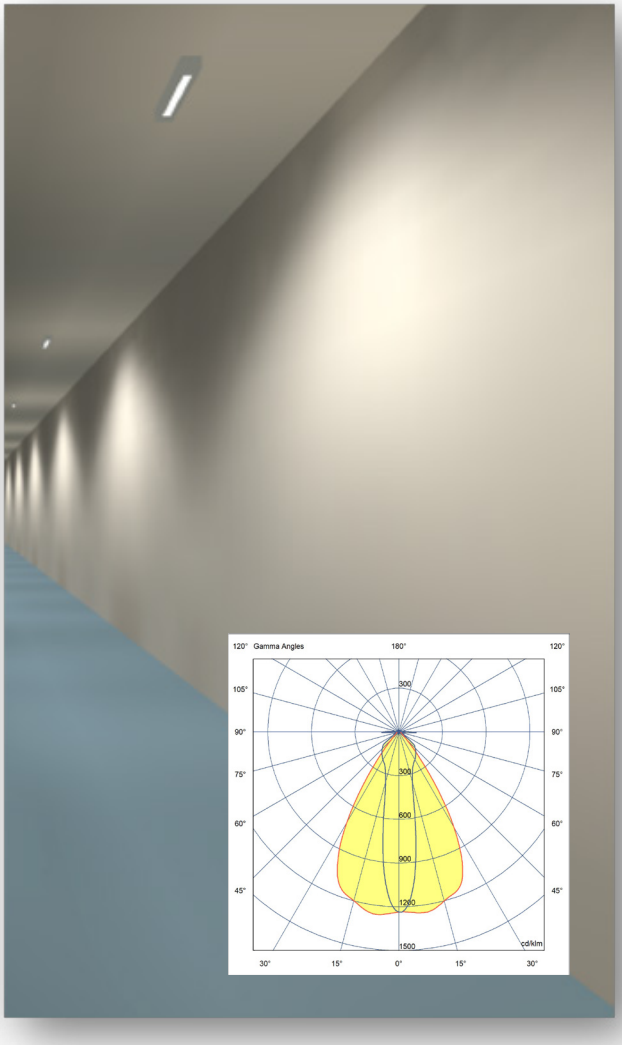
## LED Optics

The cylindrical design of a fluorescent tube means there will always be some degree of wasted light from a fluorescent fitting. In contrast, an LED luminaire can direct 100% of its output towards the ground where it's needed. Furthermore, the latest LED luminaires, such as SPARTAN Linear, are now available with a choice of secondary optics (a method of directing light into a controlled beam). These optics can be used for different applications, such as aisle, corridor or perimeter lighting schemes.



A Linear luminaire with these optics gives specifiers more flexibility when designing a lighting scheme and ensures light can be targeted exactly where needed to deliver maximum efficiency. By targeting the light only where it's needed, end-users can benefit from higher-quality lighting schemes with improved uniformity, and can also reduce the number of luminaires required across a lighting scheme and save costs




The example images above show a lighting scheme of a typical corridor application. On the left, an LED Linear luminaire with a standard beam angle (designed to replicate the light distribution of traditional fluorescent) is being used. We can see the light on the ground has poor uniformity, with dark areas between each light fitting. On the right, is the same design, using the same LED luminaire, fitted with an optic specially designed for use in corridors. We can see that this delivers far better results, with improved uniformity and no dark areas between light fittings.

# 3. Suitability to Harsh Environments

The data and graphs used to compare performance have already shown that an LED luminaire provides a significant performance advantage when being used in areas subjected to extreme temperatures. Exposure to these temperatures is not uncommon; temperatures in the Middle East for example regularly exceed 40°C at which point the performance of a fluorescent will begin to deteriorate significantly. In contrast, an LED luminaire remains largely unaffected.

The effect of cold weather also has a debilitating effect on fluorescent technology; at -20°C a fluorescent fitting will lose around 80% of its original output. In contrast, LEDs perform better the cooler they are. This means they'll provide a small increase in performance in cold temperatures. Taking into account the environment and how it affects the performance of a luminaire is therefore far more important than simply taking a stated lumen output figure from a manufacturer's product datasheet.

Extreme temperatures are not the only variable a fitting is exposed to in harsh environments. Luminaires are often exposed to areas of high vibration and may have to withstand occasional high impact. Fluorescent fittings are susceptible to vibration; the cathode located inside the tube is prone to coming loose which causes the fitting to fail. In contrast, an LED alternative such as SPARTAN uses a number of small profile, surface-mounted LEDs, which will not suffer at all under heavy vibration. They also receive further protection by being encapsulated in a silicone rubber potting, helping to ensure light output is preserved and maintenance is reduced.

The mechanical build of a fluorescent luminaire is also more susceptible than an LED equivalent. The majority of traditional boat fittings are manufactured from GRP plastic which is not as durable as the aluminium body of SPARTAN Linear, especially when exposed to high temperatures and high UV levels. Over time, exposure to high solar levels will degrade the plastic to the point where features such as the hinges will become brittle and risk snapping during maintenance.

*Pro-Tip When selecting a Linear luminaire, don't just consider the manufacturer's lumen output. You should also take into account the efficiency of the fitting and how it will perform in the environment of the application.*

# 4. Maintenance

It could be argued that carrying out regular maintenance work on the fluorescent fittings would ensure a more consistent performance level and would bypass the problem of degradation which has been demonstrated earlier in the white paper. While this is true to an extent, frequent maintenance in practical terms comes at a significant expense. It's a topic we covered in detail in a previous Raytec white paper, 'Modular Ex Lighting – How it Delivers Huge Savings'. Luminaires certified for use in hazardous areas are often installed in locations where access is restricted, and gaining access can be a costly exercise. For example, it may require rope access, the use of specialist machinery, or for part of the site to be shut down for maintenance to be carried out. The long life of LEDs, without the need for relamping, means significant maintenance savings over the course of the product life.

Choose a fluorescent installation and you'll be facing a constant battle of maintenance and upkeep to achieve a level of performance to compete with an LED fitting; which begs the question; why wouldn't you go with LED in the first place?

Some may argue that despite the reduced cost of maintenance, an LED fitting can still prove less cost-effective in the long run; although a fluorescent tube will fail over time, the fact that the luminaire's enclosure can still be used once new tubes have been installed prevents the need of having to replace the entire unit.

However, this is still possible with LED units (provided the LED unit has been designed with maintenance in mind and features modular, interchangeable parts, as all SPARTAN products do). It's actually just as simple to replace an LED module on an LED luminaire, as it is with a fluorescent tube, meaning there is no reason why the housing on LED units cannot be recycled in the same way as a fluorescent - the only real difference is the length of time between replacements and the durability of the housing.

SPARTAN's modular design allows for easy maintenance and means spare parts can be kept on-site

*Pro-Tip The performance of LEDs is constantly improving. For an end-user looking to replace the LED module of their fitting after 100,000+ hours of operation, the performance advantage over fluorescent after this time is likely to be even greater thanks to the development of LED technology.*

# 5. Other Considerations

## The Costs of Relamping

With a fluorescent tube having a much shorter life than LEDs, requiring frequent maintenance and relamping, each fitting will go through many fluorescent tubes throughout its life. As well as the cost of maintenance, there are two other notable costs associated with frequent relamping which should also be considered;

### Availability of Fluorescent Tubes

The T5 and T8 fluorescent tubes which are commonly used in Ex-rated luminaires are due to be banned from being placed on UK and EU markets from August 2023.

The ban on fluorescent tubes has been introduced as a result of changes to the RoHS directive and due to the fact they contain mercury (considered a hazardous substance). Although the use of mercury in electrical equipment is already prohibited, T5 and T8 fluorescent tubes have previously been exempt as 'special purpose' lamps. However, the latest amendments to the RoHS directive will see this exemption removed and the ban will come into place on 25th August 2023.

While the ban will prevent the tubes from being 'placed on the market', T5 and T8 tubes may still be available via resale channels for a limited time as wholesalers look to stockpile them. However, prices are likely to rise significantly during this time, and once stocks are depleted there will be no availability.  Instead, end-users are being encouraged to upgrade to LED luminaires.

*Pro-Tip In the coming years similar restrictions could also be placed on HID lamps, including metal halide and mercury vapour, which are commonly used in traditional Ex-rated floodlights. While the sale of luminaires using this technology hasn't yet been prohibited, they have been limited to a 3 to 5-year exemption as part of the latest updates to the RoHS directive. This may well mean a ban, similar to the one imposed on fluorescent tubes, will be introduced in the future.*

### Disposal

The presence of mercury and other phosphors in the fluorescent tubes also means there are strict regulations in place to control their disposal. Mercury is an important toxic pollutant which makes the tubes an environmental hazard.

As well as the cost associated with the process of recycling the tubes, for offshore applications there is the added expense involved in transportation. To be recycled safely fluorescent tubes must be returned to the mainland for safe disposal, likely using a supply boat or helicopter, incurring significant transportation costs.

There is also the risk of new tubes being smashed during transportation which poses a health hazard. While there are no such hazards or regulations to comply with during the disposal of LEDs, the main benefit and cost saving come from the much longer life of 100,000+ hours without the need for relamping.

## Quality of Output

While we've discussed the performance advantages of LED over fluorescent in terms of the level of light output, the quality of output is also important to consider.

A noticeable difference between fluorescent and LED fittings is the colour temperature; fluorescents typically use tubes with a colour temperature of 3,000-4,000k, providing a 'warmer' white light compared to many LED fittings. LEDs are available with higher 'daylight' colour temperatures of 6,000k which can be used to help improve working conditions. LEDs are available in a wide range of colour temperatures meaning end-users can still specify a luminaire with a warmer output if preferred. As an example, accommodation modules typically use a 4,000K colour temperature which is more suitable for indoor, domestic type applications.

The quality of light across a site is also affected by the failure rate, light degradation, and susceptibility to extreme temperatures of fluorescent luminaires. With more frequent failures and performance drops, the length of time will increase in which a site is left with areas of darkness, insufficient light levels, or poor uniformity. This has an impact from a health and safety perspective and heightens the level of risk on-site. This issue will also worsen under emergency conditions.

*Pro-Tip LEDs are available in a wide range of different colours and colour temperatures, meaning the fitting can be tailored to meet the requirements of an application.*

## Performance Under Emergency Conditions

When mains power fails, a site often relies on emergency lighting to maintain safety and provide illumination which is necessary to carry out important evacuation procedures. A reliable emergency fitting is therefore essential, and fluorescent fittings (especially with older units) have a tendency to fail when suddenly switching to run at a lower power. This is largely due to the performance of components (such as the ballast or starter) beginning to deteriorate and being unable to provide the necessary punch to restart the tubes using the emergency battery.

Another limitation of an emergency fluorescent fitting is that during a 3-hour emergency period, the output level will decline significantly. In contrast, the light output of an emergency LED luminaire will remain constant throughout, without any drop in light levels through the full duration of the battery backup period.

Additionally, because the performance of a fluorescent luminaire dips dramatically under extreme temperatures, emergency performance is also severely affected. A fluorescent will generally be designed to provide 40% of its light output under emergency conditions (with each tube dropping to 20% power), but when taking into consideration the effect of a cold environment, the performance in emergency mode can be practically obsolete in some applications.

In contrast, an LED luminaire provides a much more reliable emergency solution. The LEDs will run at any power in any temperature, and the consistency of performance in extreme temperatures means the emergency output remains at an effective level to meet the demands of the application. Because LEDs are so much more efficient, units like SPARTAN can be offered as variants with up to 100% output on emergency.

### LED Emergency Fitting

# Summary

As well as delivering improved performance, both in terms of level and quality of light output, the suitability of LED technology to harsh environments makes it a far more consistent and reliable solution compared to fluorescent luminaires. LED Linear luminaires offer a performance advantage from the initial installation; an advantage that only grows over the medium to long term as fluorescent fittings degrade, fail and require frequent maintenance.

The extent of the performance advantage which an LED Linear delivers, especially with the very latest products such as SPARTAN Linear High Output, means smaller, more cost-effective solutions can be used to deliver superior performance to larger versions of existing fluorescent fittings. The Linear High Output products also represent a step change in how Linear style fittings can be deployed, capable of being installed at increased mounting heights and in place of traditional Bay luminaires.

Combine this performance advantage with the fact that the sale of fluorescent tubes will soon be banned in the UK and EU (from 25/08/2023), and the need to upgrade from fluorescent to LED is more pressing than ever.

*At Raytec we love to talk lighting, so speak to us about your application at sales@raytecled.com, call us on +44 (0)1670 520 055, or visit www.raytecled.com to discover our full range of SPARTAN Ex LED luminaires.*

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