

Raytec White-Paper Comparing Technologies and Specifications

LEDs are the lighting solution of the future. To understand lighting you must understand LED technology and its relative merits against both other lighting technologies and other night-vision techniques

Sources of Light

Light Emitting Diodes (LEDs) are semi-conductors that naturally emit a narrow band of light, are highly reliable and very small, making them suitable for a number of lighting applications. LEDs are the fastest growing lighting solution in the world and are now used for everything from lighting for surveillance, lighting for vehicles, domestic lighting and now, even for street lighting.

Advantages

Efficacy:	Greater output of light per watt than most technologies.
Long Life:	LEDs have a useful life of over 44,000 hours (10 years continuous night-time use) with time to complete failure even longer.
Slow Failure:	LEDs will degrade slowly over time rather than experience the catastrophic failure of a typical bulb
Start up time:	LEDs can reach full brightness in 10-20 nanoseconds and can re-start just as quickly.
Pulsing:	An LED can be powered on/off multiple times per second for prolonged periods without damaging product life.
Power adjust:	LEDs power can be both dimmed or boosted to react to different on scene requirements very easily.
Resistant to Vibration:	As LEDs are solid state devices, and have no fragile filament, they are durable and resistant to vibration either from wind, transport or re-location.
Highly Directional:	With the use of small optics LEDs can provide a precise and highly directional beam pattern. Bulb based illuminators often require large reflectors to focus the light beam and even then it is difficult to control the direction of the beam efficiently
Size:	LEDs are small and can lead to much smaller and neater illuminators
Precise Wavelengths:	LEDs are developed to emit an exact wavelength or colour of light without the need for additional filters which means LEDs can deliver light more efficiently, run at lower operating temperatures all at a more cost effective price.

Since the 1960s the performance of LEDs has increased significantly with developments in LED technology, optics and materials science allowing lighting output to be doubled approximately every 36 months.

Disadvantages

Purchase Price:	LEDs have a higher initial purchase price than old technology lighting. However long life-times together with energy, maintenance and CO2 savings mean that LEDs can be a cost effective solution in the medium to long term.
Efficacy Droop:	As current is increased through an LED the efficacy of the unit decreases. However, this can also be an advantage of LEDs - making it possible to maximise light output at the expense of efficacy or vice-versa depending on the specific needs of an installation.
Temperature Sensitivity:	Both LED performance and lifetime depend on both the ambient temperature and the thermal control of the illuminator. Overheating an LED dramatically reduces operational life.

LEDs advantages versus traditional technologies vary depending on the other technology in the comparison.

Key Aspect	Tungsten	Halogen	Fluorescent	CFL	Low Pressure Sodium (SOX)	High Pressure Sodium (SON)	Metal Halide (HQI MBI)	Raylux LEDs
Efficacy [1] (lm/w)	10-12	15-25	60-95	65-70	180-200	90-120	70-80	55-75
Operational Hours	1,000	2,000-4,000	9,000-20,000	9,000-15,000	7,500	20,000-24,000	15,000-20,000	44,000+
Quick Start*	Yes	Yes	No	No	No	No	No	Yes
Health & Safety Concerns	No	No	Yes	Yes	Yes ^[2]	Yes ^[2]	No	No
Dimmable	Yes	Yes	Yes	Yes	No	No (yes in steps)	No	Yes
Good Colour Rendering	No	No	Yes**	Yes**	No	No	Yes	Yes
Flicker Issues	No	No	Yes***	Yes***	Yes	Yes	Yes	No
Cold Temperature Sensitive	No	No	Yes	Yes	Yes	No	No	No
High Temperature Sensitive	Yes	Yes	Yes	Yes	No	No	No	Design Dependant
Beam Control	Yes	Yes	Limited	Limited	Limited	Limited	Limited	Yes

* Almost full light output immediately

** Modern dat tubes provide good colour rendition

*** Usually in older technologies

LED lighting vs other technology lighting



Sodium Lighting



LED Lighting

In this test a fence line and an area up to 5m inside the fence line needed to be illuminated using existing lighting columns. The LED solution produced a better colour representation, a better quality of light for the CCTV camera and lowered electrical consumption and maintenance costs. Importantly, the image illuminated by LED lighting shows that the fence line is inside an external wall, the image illuminated by sodium lighting makes the wall and fence look indistinguishable.



High Pressure Sodium Lighting



LED Lighting

In this recent installation a power station was using High Pressure Sodium lighting to illuminate a work area. Switching to an LED solution produced a much better image and better colour rendition. Importantly the colour of all the machinery, switches and dials is much clearer under LED lighting.

Comparing Sources of Light

Incandescent Lamps (including Halogen)



Bulb life is limited and they are highly inefficient making them expensive to run (typically 500W) and to maintain (up to 3 bulb changes per year). End users are increasingly moving away from using halogen based lighting products in favour of longer life LEDs and many governments are taking steps to ban incandescent lighting.

Incandescent bulbs were the first bulbs developed and are highly inefficient, wasting 90% of their input energy as heat. Their heat output is such that they are extremely hot to touch and can heat surrounding objects in close proximity.

Halogen bulbs provide a minimal increase in efficiency but still waste as much as 85% of their input energy as heat. Halogen bulbs are smaller and higher pressure than incandescent bulbs causing them to have extremely hot surfaces hazardous to the touch. Bringing the bulb into contact with cold surfaces such as residue from fingerprints, particularly sodium, may cause bulb failure.

Fluorescent Lamps



Their use for CCTV purposes is limited due to the perceived "beating" effect when used with a CCTV camera. They are generally low power and designed mainly for internal fitting. As they have a large diffused source the light output is difficult to focus and control.

Fluorescent bulbs are much more efficient than incandescent bulbs, operating at approximately 40% efficiency. Only 60% of the input energy is wasted as heat so fluorescent lamps run much cooler than incandescent lamps and can provide equivalent power from much lower electrical inputs. For this reason, and the fact that fluorescent lamps tend to last 10-20 times as long as an incandescent bulb, they are commonly used in domestic homes as long life bulbs. However, fluorescent lamps produce a flicker imperceptible to the human eye but visible to cameras as a "beat" effect making fluorescent illumination unsuitable for video surveillance. Fluorescent lamps also contain the hazardous material mercury.

HID Lamps



HID lamps can be used for CCTV and general area lighting. They are efficient, provide good colour rendition (except low pressure sodium), and are long life – typically up to 12,000 hours. However, they suffer from a slow start (up to 5 minutes) and cannot be turned on immediately after being turned off.

High Intensity Discharge (HID) lamps are 60-80% efficient and compared to incandescent and fluorescent lamps provide much more light from a smaller package. HID forms include low pressure sodium (unsuitable for CCTV due to its yellow colour output), high pressure sodium (more acceptable but produces worse colour rendition than Metal Halide) and Metal Halide. Metal Halide HID bulbs provide a very natural, cool clear White-Light with excellent colour discrimination. However, they still cannot match the quick start or long life of LEDs. HID lamps are commonly used for street lighting and in car headlights.

LEDs



LEDs are the fastest growing lighting solution on the planet. They are extremely efficient and offer unbeatable reliability. LEDs offer the lowest running costs (less than 100 watts for the largest units) with the longest operating life and lowest maintenance factor.

Light Emitting Diodes (LEDs) are semiconductors that naturally emit a narrow band of light. They are a relatively new development in lighting but their usage is expanding rapidly on the back of their clear technical advantages. LEDs are comparatively expensive to purchase but provide extremely long life up to 100,000 hours. In comparison fluorescent bulbs typically last 10,000 hours and incandescent bulbs 1,000. LED efficiency is typically 80-90%. The advantages of LEDs are multiple and are listed on page 2 in detail. They include extremely low electrical consumption, low operating temperatures and continuity of colour throughout the operating life of the LED. Unlike traditional bulbs LEDs are also highly durable, resistant to vibration and their hard casing makes them difficult to break. They are quick start devices and are also capable of emitting light at a given wavelength without the need of a filter.

Comparing different LED technologies

Not every LED is equal. The general development of LEDs falls under 3 main categories

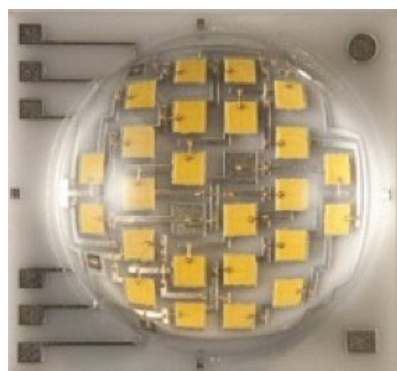
Low Power



High Power



Multi-Chip



Low power LEDs are typically of the through-hole variety. They tend to be very basic and generate small amounts of light with limited heat management.

High power LEDs are typically surface mount technology (SMT) which gives the LED itself a large flat surface area to be mounted to the PCB. This makes it easier for the LED mounting system to be mechanized, allowing a precise and uniform mounting pattern and also provides a larger surface area to dissipate heat. With the larger surface area SMT LEDs can be driven harder without compromising performance. High power LEDs generate far more light and far more heat than low power LEDs so thermal management of these LEDs is crucial. Without adequate thermal management and heat sinking high power LEDs will fail quickly.

Multi-Chip LEDs are designed for applications where size is critical. These LEDs concentrate a number of individual LEDs (either low or high power) into a small area. They can also focus the light to allow the beam pattern to be more tightly controlled. However, multi-chip LEDs, because of their close proximity, generate large amounts of heat which make thermal management and life control difficult. Multi-chip LEDs can compromise on lifetime to produce light from an extremely small package.

In the same way that most camera manufacturers do not manufacture their own CCD or CMOS chips, typically illuminator manufacturers do not develop their own LED chips, they use LEDs manufactured by specialist LED chip manufacturers. This means that power management, thermal management and optics are the most important factors to ensure LEDs deliver on their expected performance and achieve the lifetime and light levels that they are capable of. Not only are all LEDs different, but the same LED in different hands delivers very different results.

***Pro-Tip** For surveillance lighting or lighting for safety critical environments, where the size of the illuminator is not restricted, it is better to use a quantity of High Power LEDs to provide a product with the best light output and life expectancy rather than using a multi-chip LED package or the less powerful LED chips.*

***Pro-Tip** Two lighting manufacturers can use the same LED in their illuminators but achieve significantly different light output and reliability depending on the quality of their thermal management, heat sinking and optical system developed around the LEDs – as well as internal quality control procedures.*

Choosing which Wavelength of Light

White-Light

- White light is a mixture of visible wavelengths from approximately 400nm to 700nm.
- It covers all the colours of the visible spectrum from red, orange, yellow, green, blue, indigo and violet.
- The human eye is at its most sensitive at around 555nm, in the green range of the visible spectrum.
- White-Light provides the opportunity to illuminate an area for multiple uses: Pedestrians; CCTV; staff or vehicles.
- White-Light can be used as a visual deterrent – activated when an intruder enters a secure area.

Infra-Red

- 715-730nm is overt, visible Infra-Red. It produces a red glow like a traffic light. It is not widely used for LED illuminators and tends to be a legacy option from old fashioned Halogen style illuminators.
- 815-850nm is semi-covert Infra-Red. It produces a very faint red glow only just visible to the human eye. Most IR sensitive cameras are fully capable of seeing 815-850nm.
- 940-950nm is covert IR, virtually invisible to the human eye. However the sensitivity performance of all CCTV cameras drops significantly with 940nm, by as much as 50% - with achievable distances dropping accordingly. CCTV lenses are also less efficient with 940nm light.
- Because Infra-Red illuminators produce light at one given wavelength and White-Light illuminators need to deliver a range of colours to produce White-Light, IR illuminators can cover longer distances.
- Infra-Red illuminators can be used to provide semi-covert or covert illumination without creating any light for an intruder or any light pollution.
- Infra-Red light can only be viewed with a camera system.

The best solution for most Infra-Red applications is 850nm. It is both more discreet and more powerful than illuminators using 715-730nm LEDs and achieves much greater distances than 940-950nm illuminators as camera sensitivity seriously inhibits performance with 940-950nm illuminators. Focussing is also more difficult at 940-950nm and 'focus shift' between day and night images is more likely to occur.

Comparing Infra-Red and White-Light

	Advantages	Disadvantages	Camera Type Suitable
White-Light	Visible deterrent	Light pollution	Colour
	Full colour rendition	Reduced distances	Day/Night
	Easy set up		Monochrome
Infra-Red	Discreet or covert	Limited deterrent	Day/Night
	Longer distances	More difficult to set up	Monochrome
	No light pollution		

Pro-Tip An 850nm illuminator can produce less radiant flux (power) than a 940nm illuminator but still achieve significantly further distances because cameras tend to be around 50% less sensitive to 940nm Infra-Red.

Measuring Light and Comparing the Power Output of Different Illuminators

Typically the security industry has simply quoted maximum distances and angles of illuminators without the publication of any technical data to back up those claims. As more manufacturers now provide illuminators those marketing claims have now become more and more aggressive and it becomes increasingly important to understand how illumination distances and angles are calculated.

Measuring White-Light

The advantage with White-light is that it is visible to the human eye so beam patterns and distances can be easily evaluated – unlike Infra-Red light.

There are two important measurements for White-Light illuminators:

- 1) Lumens are used to measure the total amount of visible light emitted by an illuminator (luminous flux).
- 2) Lux measures the amount of luminous flux (number of lumens) falling over a given area. It is a measure of illuminance to measure the intensity of light on a surface. 1 lux is equal to one lumen per square metre

The Lux level at any given point depends on a number of factors including output angle, installation height, mounting angle and distance from the illuminator. In North America the foot candle is still widely used as a unit of measurement. 1 Lux is approximately equal to 10 foot candles (10.764 to be precise).

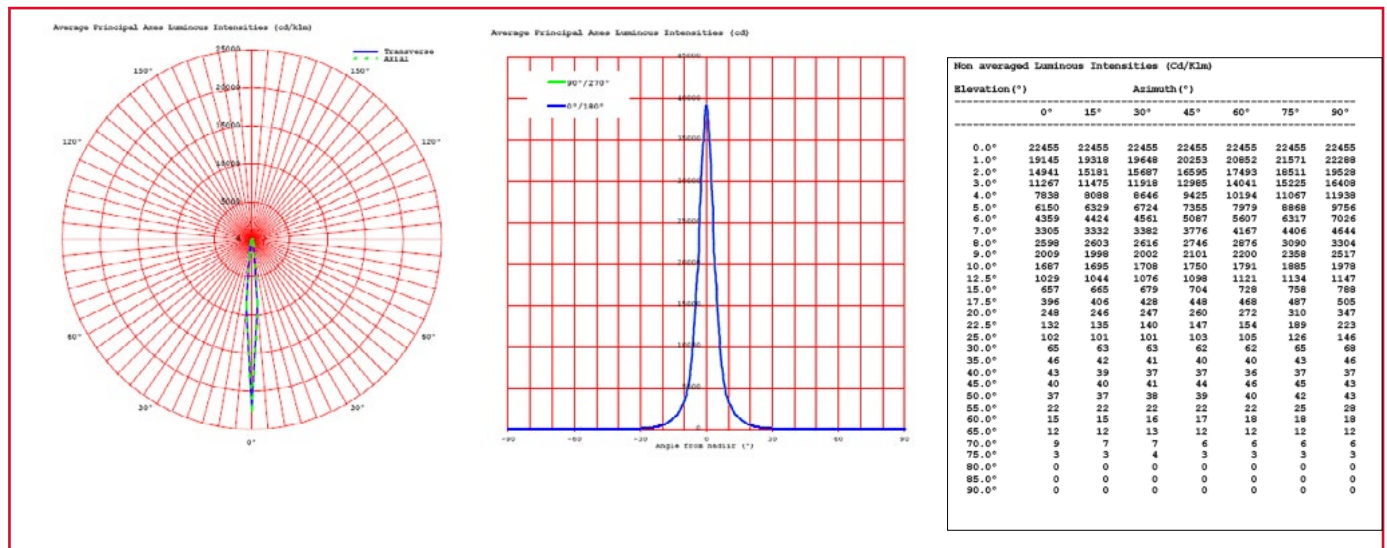
*Pro-Tip Understanding lumen output (luminous flux) vs Lux levels:
Consider a Raytec illuminator with a variable output angle of 30-60 degrees. If the angle of the illuminator is increased from 30 to 60 degrees the lumen output remains constant but illumination over a 1m square section of the scene (Lux) decreases.*

Pro-Tip Manufacturers should use the total number of lumens (luminous flux) on datasheets as an absolute measure of White-Light power output. Because Lux levels are dependent on a number of installation factors they cannot be specified at product level – only measured as part of the installation and commissioning process. It is the quantity and the distribution of the light that together govern the quality of the illumination.

The White-Light Measurement Process

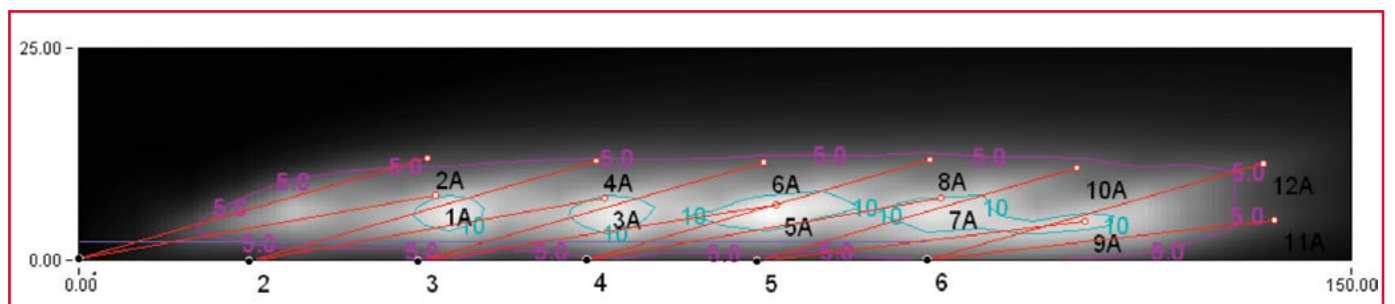
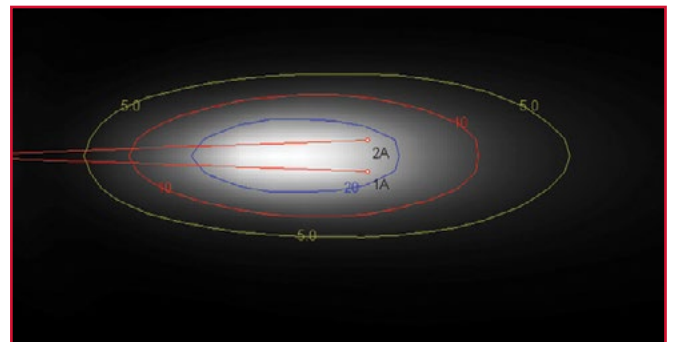
Every White-Light illuminator should have independent photometric testing to confirm performance. Without independent test data there is no credibility to the distance or performance claims of a White-Light illuminator. The photometric testing measures the illuminator in a spherical chamber to capture all the light emitted by a source and then testing is done to plot illumination output at different angles.

1: Independent photometric testing delivers precise data on each illuminator which can be loaded into a lighting design software package



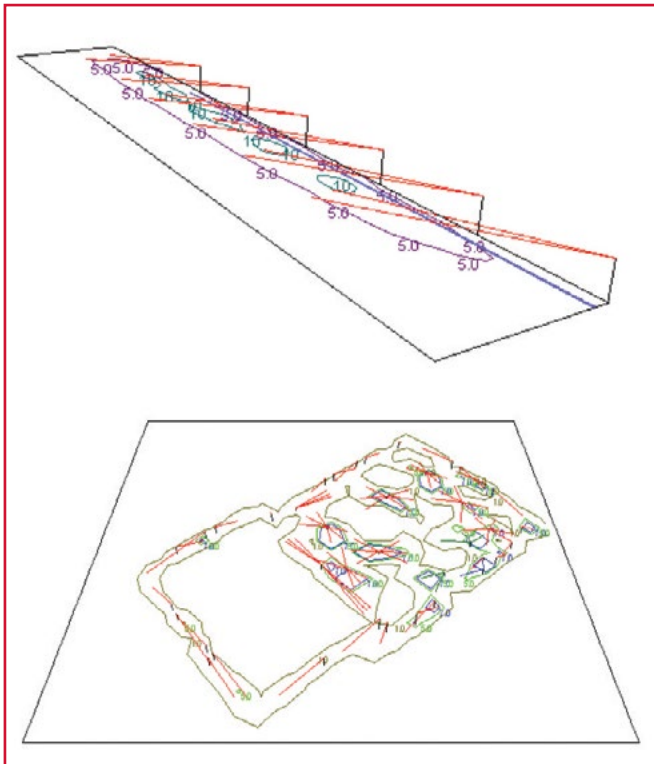
2: This raw data, added to site-specific data such as mounting height and mounting angle, can then be used to plot the performance of a single illuminator in a lighting design software programme – and for multiple illuminators.

The example below shows multiple White-Light illuminators being used along a perimeter fence line.



3: The 2 dimension data can be plotted into 3D plans for more detailed and accurate information.

The example below shows a 3D plan of the perimeter fence line, and of the lighting scheme for the entire site.



Raytec also have the ability to construct a full 3D lighting model of the entire site, if required:



***Pro-Tip** Raytec photometrics provide total lumen output of an illuminator (measured in an integrating sphere) together with the distribution pattern of an illuminator. This data allows us to plot light levels across a scene (in Lux) given specifics of the installation including mounting height, mounting angle and subject distance.*

Measuring IR

Assessing the performance of Infra-Red illuminators is much more difficult than assessing the performance of White-Light because a lighting design cannot be evaluated with the human eye; it must be viewed through a camera and lens and the performance of the camera and lens affects the way the IR performance is perceived. However, the specification and measurement of IR can be done in exactly the same way as a White-Light illuminator, it just requires a different sensor to measure the IR.

Traditionally IR illuminators have been measured in terms of the distance they can illuminate. However, this system fails to measure the true performance of an illuminator before the impact of the camera and lens, and is highly subjective and open to manipulation and misrepresentation.

Consider an IR illuminator such as the RM100-AI-30. If we quote the distance of this illuminator as 100m what does it mean?

First we must understand the relationship that the lens and the camera sensor have on our perceived performance of the light.

The Effect of the camera lens

The f number of a lens is a mechanical ratio and describes the amount of light passed through the lens to the camera sensor. Essentially the smaller the f number the more light passed to the camera sensor. Below is a table showing the light passed through the lens by f-stop rating using an F1 lens as the base number

F-Stop	F1.0	F1.2	F1.4	F1.8	F2.0
Light Passed (as a %)	100%	69%	51%	31%	25%

Pro-Tip A simple calculation to determine how the F-Stop rating affects the light capable of passing through a lens can be written as 1 over the f-stop² (for example an F2.0 lens passes 25% of the light because 1 divided by (2²=4) = 0.25. The transmission characteristics of a lens will further impact the amount of light transmitted.

The Effect of Sensor Size

The light collected by individual pixels of a camera is proportional to the size of the pixel. So with a 3MP camera with a resolution of 2048 x 1536 pixels, the size of those individual pixels will be larger on a 1/2" camera than on a 1/4" camera, they will each capture more of the available light so the 1/2" camera will require less light to power an image. Below is a table showing the relative size of different camera sensors.

Size of Sensor	1/2"	1/3"	1/4"
Sensor Area (mm2)	36	17	9

To consider the affect that different camera and lens combinations have on the perceived performance of an IR illuminator take an example scene that has 100 mW on scene

Size of Sensor	1/2"	1/3"
Sensor Area (mm2)	36mm	17mm
Relative Sensor Size	100%	47%
F-Stop of lens	F1.0	F1.4
Light Passed (as a %)	100%	51%
Light power available to sensor	100mW	24mW

NB: equation is "light power on scene x light passed through lens x any variable for relative sensor size"

You can see that a 1/2" camera using a F1.0 lens needs 4 times less light than the 1/3" camera with a F1.4 lens. These variables greatly affect the maximum stated distances manufacturers quote for illuminators.

Raytec traditionally base maximum illumination distances on systems using a 1/3" camera with a F1.4 lens. Camera manufacturers themselves tend to use a F1.4 lens for their sensitivity claims.

Pro-Tip To compare the distance claims of two different IR illuminators you must check the test set-up to achieve those claims. A 1/2" camera with a F1.0 lens will require 4 times less light than a 1.3" camera with a F1.4 lens.

Light and Eye Safety

The IR measurement process

True IR power output is measured as radiant flux being the total power output of all light emitted from a source, regardless of the eyes ability to see it. Radiant flux is the IR equivalent of a White-Light illuminators "luminous flux".

IR power on scene is measured in microwatts per centimetre². Raytec test all our illuminators for power output at a distance of 3m from the illuminator source. Using the inverse square law we can then calculate the exact IR power (in μW per cm^2) at any distance away from the illuminator. We calculate the maximum distance of an illuminator based on the minimum amount of illumination needed on scene to produce an acceptable picture with a 1.3" camera and a F1.4 lens.

We measure IR power on scene over a cm^2 area because that allows direct readings from a power meter. WL power on scene is measured over a m^2 (lux) which is the established standard. Lux meters actually measure the light over a much smaller area and multiply the result up to give the equivalent result over a full square metre

To help raise standards and awareness Raytec will start to publish both maximum illumination distances (subject to camera and lens performance) and absolute power output data (radiant flux) for all IR illuminators.

Comparing IR and White-Light Measurement

	Terminology	Unit of Measurement
White-Light total light output	Luminous Flux	lumens
Infra-Red total light output	Radiant Flux	Watts
White-Light on scene	Illuminance	Lux (lumens per m^2)
IR on scene	Irradiance	Watts per metre ² / μW per cm^2

***Pro-Tip** Raytec distances are based on achieving an absolute minimum of $0.132\mu\text{W}$ per cm^2 power on scene at the maximum specified distance*

As White-Light is visible to the human eye we have a natural protection against an overexposure to White-Light. The iris and the eyelids close to reduce the input of visible light. If this does not suffice we simply turn away from the light.

As we cannot see Infra-Red our eyes cannot automatically adjust to protect from overexposure. However, Infra-Red does produce heat – it is the Infra-Red we can feel on a hot sunny day as warmth. It is this heat from Infra-Red that we can use as an indication of safety. The general rule of thumb is that if you can feel the heat of the IR unit then do not look directly at the source.

Even the most powerful IR units, at angles of 10 degrees, are fully eye safe beyond distances of 2m.

Raytec take eye safety very seriously. All Raytec IR products including RAYMAX, PLATINUM and FUSION illuminators have been tested and classified as Class 1M laser devices. A Class 1M laser device is safe for all conditions of use with the naked eye. Class 1M lasers produce large-diameter beam patterns, or beams that are divergent. The MPE (maximum exposure time) for a Class 1M laser cannot normally be exceeded when viewed with the naked eye.

***Pro-Tip** If you can feel the heat of the light source, do not directly at the light.*

Evaluating Running and Maintenance Costs

When you switch to low energy LED illuminators delivering low running costs and long life, an organisation such as a hospital, using 100 CCTV and security lights could be saving £46,000 per year, and these savings are only set to increase as energy costs increase!

Environmental and energy consumption issues are high on the global agenda. Given that £1 from every £5 spent globally is used on lighting, and much of this spend is on inefficient or unnecessary lighting particular attention should be given to this area. The pressure to save energy by looking at running costs, maintenance costs and an organisation's carbon footprint will only increase as energy costs increase. Both public and private sector users are looking for methods to reduce costs and minimize their energy requirements and lighting should be one of the first points on the agenda.

Traditionally lighting has been delivered by mains powered lamps and although some lamps are more efficient than others the future of light lies with Light Emitting Diodes (LEDs). Low energy LED illuminators deliver lower power consumption, lower running costs, zero maintenance and provide longer life compared to older style lighting which can also be extremely slow to start up.

LED illuminators are a highly efficient light source which can deliver huge savings to end users.

Pro-Tip Switching 100 old style 500W mains driven illuminators to 100 RAYLUX LED illuminators could save £460,000 over the 10 year life of the system, improve security and save 800,000 kg of CO₂.

Pro-Tip Payback time in switching to LED illuminators is typically between 1 and 2 years compared to Halogen illuminators.

A Comparison of the Annual Costs of Different Individual Illuminators

	Mains Driven Bulb	Low Voltage Halogen Bulb	LED RAYMAX and RAYLUX
Electrical Consumption	500W	200W	80W
Cost of Consumption*	£220 (\$352)	£88 (\$140)	£35 (\$56)
Average Bulb Life	5 months	8 months	10 years expected life
Bulb Changes per year	2.4	1.5	N/A
Approx Bulb List Price	£75 (\$135)	£60 (\$120)	N/A
Cost of Bulbs per Year	£180 (\$324)	£90 (\$180)	N/A
Yearly Labour Cost**	£96 (\$168)	£60 (\$105)	N/A
Total Yearly Operational Cost	£496 (\$794)	£238 (\$380)	£35 (\$56)

* Based upon 4,400 hours use per year at 10p kw/hr

** Labour costs calculated at £40 per bulb

A Comparison of the Annual Costs on multiple illuminator sites

	Mains Driven Bulb	Low Voltage Halogen Bulb	LED RAYMAX & RAYLUX	Raytec Saving
10 units	£4,960 (\$7,936)	£2,380 (\$3,808)	£360 (\$576)	£4,600 (\$7,360)
50 units	£24,800 (\$39,680)	£11,900 (\$19,040)	£1,800 (\$2,880)	£23,000 (\$36,800)
100 units	£49,600 (\$79,360)	£23,800 (\$38,080)	£3,600 (\$5,760)	£46,000 (\$73,600)

LED illuminators also save on maintenance and CO₂ emissions

Total Cost Saving	£460,000 (\$736,000)
Labour Savings	2,400 fewer bulb changes
CO ₂ Emissions Reduction	800,000 kg of CO ₂

(Example 100 Raytec LED lights over 10 years)

Why switch to LED lighting:

- Potential saving on 1 illuminator of £460 (\$736) per year
- Over ten years this is a potential saving of £4,600 (\$7,360) for 1 illuminator
- Potential saving on 100 illuminators of £46,000 (\$73,600) per year
- Over ten years this is a potential saving of £460,000 (\$736,000) for 100 illuminators
- Labour saving of 2 bulb changes per year – on every illuminator.
- Over 10 years this is a saving of 2,400 bulb changes for 100 illuminators
- LEDs provide increased security (because they don't fail leaving a site unsecured while waiting for replacement parts)
- Potential saving of 667Kg CO2 on 1 illuminator, each year

***Pro-Tip** Raytec provide an interactive “Energy and Cost Saving Calculator” free of charge to help installers and end users calculate the possible savings in switching to LED technology. Visit www.rayteccctv.com to download.*

LED Lifetime – Comparing Specifications

An LED is only a long life device if it is harnessed, powered and controlled correctly. The worry for end users is that many manufacturers simply do not know the true reliability and lifetime of their LED illuminators. It isn't simply a case of using premium LEDs; it is the power management, heat management and optical management of those LEDs that affect product life and performance. Badly designed LED illuminators subscribe to the mantra of "live fast, die young". LED illuminators often have no serviceable parts so a failed product means more than a simple repair, it means a whole new unit. Not only are all LEDs not made equal, but the same LED is not equal in different hands.

To understand the lifetime of an LED it is important to consider the meaning of 'lifetime' in this context. Is it when the product no longer produces any light, or when the product no longer produces 'enough light' (sometimes defined as useful life)? For an individual LED, lifetime is considered to be the point when the LED power output falls to lower than 70% of its original value. We can use the same 70% figure to measure the output of a full LED illuminator. The US Department of Energy and the Next Generation Lighting Industry Alliance take a harsher stance, recommending lifetime of an illuminator to be "when half of the LEDs in a product have fallen to below 70 percent of their average initial light output for any reason".

***Pro-Tip** An LED's 'useful life' is considered to be when the LED illuminator will produce 70% of its original output. Because of the inverse square law we can calculate that 70% output power will achieve 84% of the original illuminator distance – a drop of only 16%.*

Raytec understand that the lifetime of an LED illuminator depends on a number of factors, the most important of which is thermal management of the LEDs. In general, product lifetime decreases as temperature increases. Raytecs' industry leading reliability and 5 year warranty package are the result of a number of quality control and quality design measures:

- Our LED technology is field proven.
- Our LEDs are powered from a constant current source to reduce the impact of major temperature increases on the electronics and environmental changes.
- Every illuminator goes through a multi-point testing process prior to despatch.
- Raytec are fully ISO9001 certified to ensure quality throughout the design and manufacturing process.
- We have developed a Cool Running Thermal Management System to effectively remove heat from the LED chips and prolong LED life.

***Pro-Tip** To compare two or more different LED illuminators is it essential to understand how manufacturers define lifetime: It could be the 70% of original output as used at Raytec, it could be 50% of original output... or it could be time to catastrophic LED failure.*

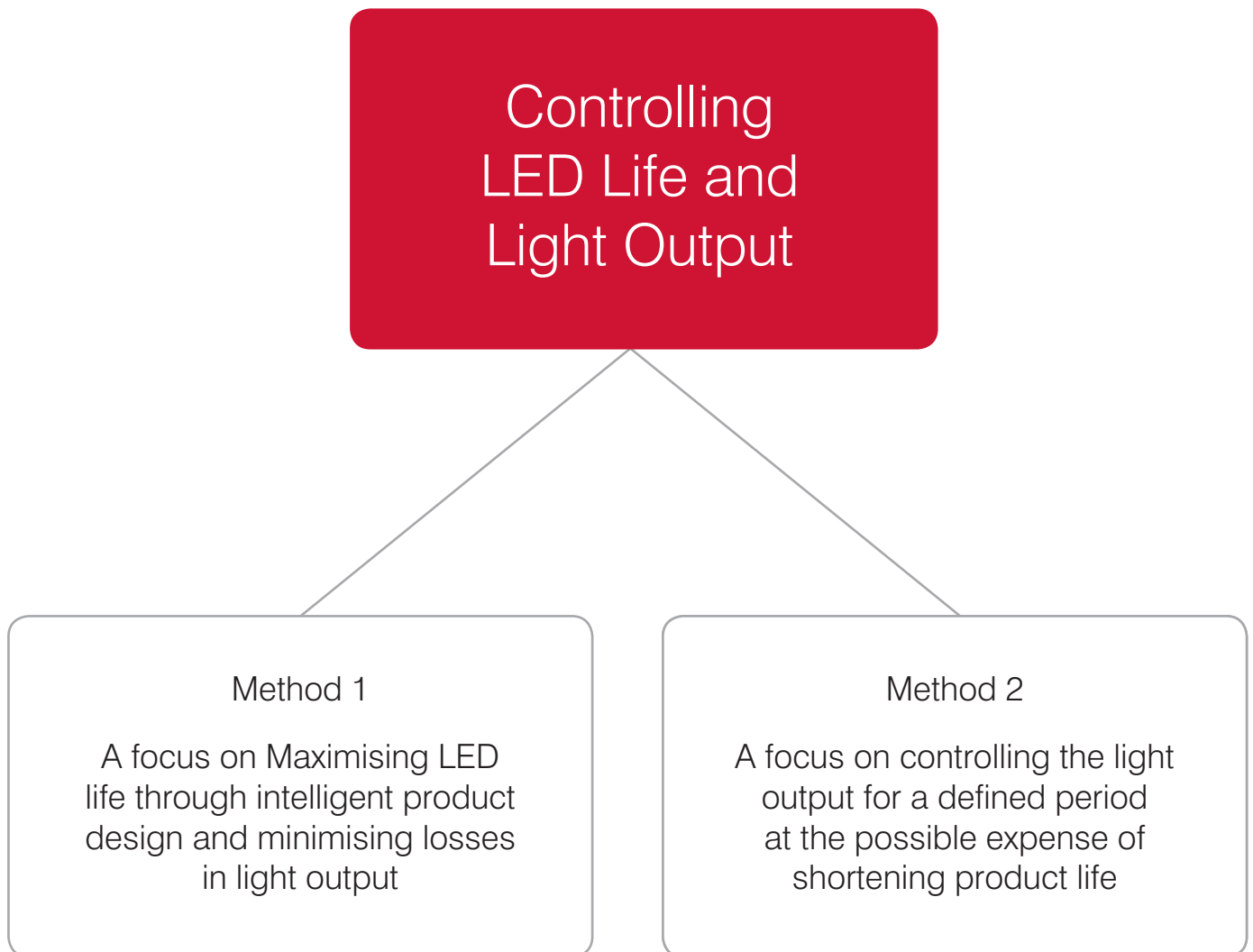
Internal vs External Control Electronics

The lifetime of an individual LED can easily be up to 100,000 hours – the equivalent of almost 23 years of full night-time usage. However, the lifetime of a full LED illuminator is also constrained by the control electronics and here we see a big difference between serviceable and non-servicable illuminators.

Normally low voltage LED illuminators (12-24V ac/dc) have electronics built into the fully sealed LED illuminator which cannot be easily accessed or replaced. High voltage (110-240Vac) LED illuminators tend to have external electronics, often in a separate box (although this separate box can be fitted to the illuminator or remote) and therefore the control electronics can be replaced, repaired and serviced when required. Given that the lifetime of a well designed and thermally managed LED illuminator will be constrained more by the control electronics than by the lifetime of the individual LED chips, this is a major advantage of external PSU systems.

Controlling LED Lifetime – the 2 Schools of Thought

Although they degrade slowly, all LEDs degrade over time. They are no different to ALL electronic components in this regard. Given that LEDs degrade the issue for manufacturers is how we control and limit this degradation. The key to remember here is that LED degradation is primarily linked to operating temperature at the LED chip.

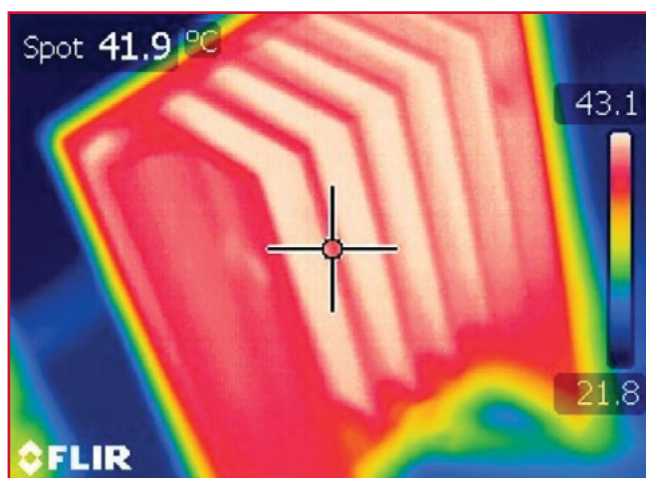


Method 1: Managing Lifetime through Intelligent Product Design

At Raytec we typically run our LEDs at 80% of their rated maximum power and work hard technically to limit the operating temperature of the LEDs and resulting degradation. For a start we supply the LEDs with constant current as it is current rather than voltage that affects LED temperature. So on a hot or cold day the units are drawing the same current. We also employ a Cool Running Thermal Management™ system to effectively dissipate heat away from the LEDs. Our LEDs are mounted to a metal substrate rather than the standard FR4 circuit board purely to help dissipate heat and we are constantly reviewing the thermal management of our products. In addition every Raytec illuminator goes through a 5 point testing process and our manufacturing process is fully certified to the ISO9001 standard to ensure the highest standards of production and testing.

At Raytec our core policy is to manage and control the LEDs effectively to create a consistent operating current and slow the LED degradation process.

The images shown are taken from heat management tests during product development. The top image shows the heatsink drawing the heat effectively away from the LEDs. The bottom image shows the LED electronics – with the areas of greatest heat generated by the LEDs themselves. Raytec take the issue of thermal management very seriously in the design of all our illuminators.



Method 2: Managing Power Output

Some manufacturers take the approach that it is best to keep a consistent light output from the illuminator. As an example, one manufacturer uses LEDs set to 60% of their maximum power (20% below Raytec) and as the LEDs start to degrade (either exact power output is measured or the LED usage can be plotted against degradation in an internal clock) power to the LEDs is increased so they start to operate at above their factory default setting of 60% in order to deliver the same power on scene.

The problem with this technique is that as the LEDs start to degrade, increasing the power and stress through the LEDs will only serve to accelerate their degradation and lead to premature product failure. So it is a question of does the customer want the longest possible life from their illuminator, or do they want a consistent light output with a shorter product life?

Recommendations for Managing LED Life

Raytec believe it is far better to control and manage the LEDs to limit their power loss, to maintain their performance, and to achieve the maximum possible lifetime from an illuminator. However, Raytec have the ability to manage power output if a particularly site requires it (via the Perma-Light function in the Pro Series PSU).

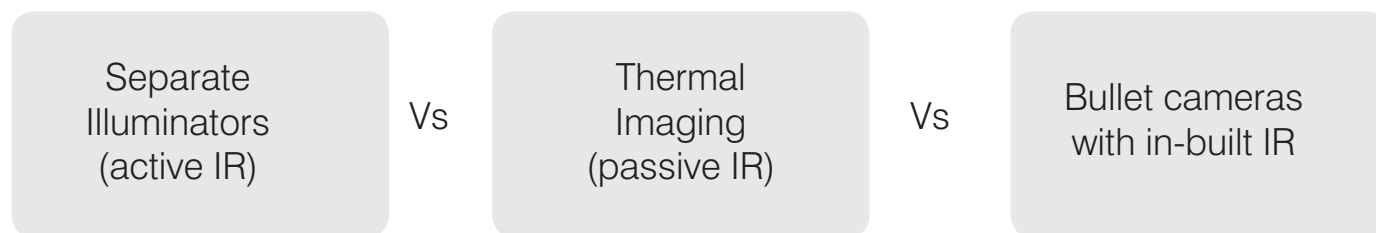
In addition Raytec are unique in providing an “Eco-Logic” function which offers significant improvement to product life whilst also delivering significant energy savings. Selecting the Eco-Logic function allows the illuminator to operate at only 50% of normal power (achieving 71% of normal distance) and switching to full power only an activation via an alarm or external trigger.

What happens if a single LED fails?

Raytec illuminators are designed in a manner which allows a few LEDs to fail without affecting the remainder of the unit. Each product is designed in individual strings of LEDs which are powered independently. For example, a unit containing 100 LEDs may be split into 10 strings of 10 LEDs. If a single LED fails then the other 9 LEDs in that string will each share the power of the 1 lost LED. If 1 string fails then the other 9 strings share the power of the 1 failed string. The result is that the power of the lost LED(s) is borne by the remaining LED(s) so the power output from the illuminator remains unchanged!

The important thing to remember here is that Raytec LEDs are factory set to operate below their maximum tolerance. This means that around 20% of the LEDs can fail and the performance of the unit will remain unchanged without damaging the lifetime of the unit.

Comparing Different Night-Vision Technologies



Active Infra-Red vs Passive Infra-Red (Thermal)

Although these technologies are both designed to provide night-vision in dark environments, they deliver very different results. In many ways they are complementary technologies and can be successfully deployed together in the high security environments.

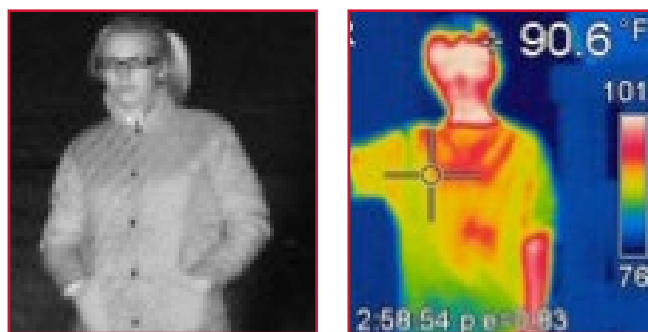
Active Infra-Red illuminators project light onto a scene to allow monochrome (black and white) or day/night cameras to produce a monochrome image. No ambient light is needed as active Infra-Red products generate light that the camera can see but the human eye does not. The results from an Active Infra-Red CCTV scene are similar to what the human eye can see during daytime – but in black and white. Facial details can be seen, lettering and logos can be read on clothing or signs and with Active Infra-Red it is possible to detect, observe, recognise and identify subjects in accordance with the UK Home Office Scientific Development Branch (HOSDB) guidelines.

Thermal Imaging relies on producing an image from variances in temperature range throughout the scene. These systems pick up radiated Infra-Red as heat signatures. The thermal camera then creates an image based on these heat measurements with some “false colours” to identify different ranges of heat. When using thermal imaging, it is sometimes easier to detect a warmer object (a person or animal) against a colder background (the ground or building) because the contrasting temperatures are represented by highly contrasting “false colours” on the monitor. For this reason it can be easier using thermal imaging to detect “something” in the scene. However, the resolution of thermal imaging systems (typically 160x120, 320x240 and 640x480 pixels versions are available) is considerably lower than conventional video. Thermal imaging cannot see facial details, lettering or logos and can only detect changes in surface temperature within the scene. Thermal imaging systems are also significantly more expensive than traditional CCTV cameras with supporting active Infra-Red.

In practice Active Infra-Red has a far greater range of uses because it produces an image more familiar, more meaningful and containing more data for humans.

For particularly high security sites it is not uncommon for Active Infra-Red and Thermal Imaging to be used together. Thermal Imaging is used to quickly detect if an object is in a scene, and then the active IR and CCTV is brought into action to identify the object / person and to evaluate the potential risk.

In the picture below, the person on the left is seen in total darkness using active IR. The person on the right is seen in total darkness using passive IR (thermal imaging)



***Pro-Tip** We call Infra-Red illumination ‘active’ because the illuminator itself generates the light the camera needs to see. Thermal Imaging is considered ‘passive’ because it relies simply on picking up information (temperatures) existing on the scene to produce a picture.*

LED Lighting	Thermal Imaging
Also known as Active Infra-Red	Also known as Passive Infra-Red
+ Produces more recognisable images	+ Can be easier to see "something in scene"
+ Can see details: faces, lettering or logos	+ Not affected by glare or changes in light on scene
+ Lower cost	- Lower resolution (max 640x480 pixels)
+ Possible to detect, observe, recognise and identify (HOSDB guidelines)	- Produces 'false' images
+ with 5MP camera can lead to 2560x1920 pixel images in total darkness	- More expensive
- Affected by glare and changes in light on scene	



5MP camera working with Infra-Red in total darkness

***Pro-Tip** A 5MP surveillance camera using active IR can produce an image of 2560x1920 pixels in total darkness. The highest resolution thermal cameras will deliver only 640x480 pixels.*

Stand alone illuminators vs Bullet Cameras with in-built IR

Bullet cameras with in-built Infra-Red LEDs are widely deployed in large numbers for low security sites such as residential buildings and convenience stores. However, they are not suitable for high security sites, for large perimeters or remotely monitored sites for 3 main reasons:

1) The lifetime of LEDs in stand along units will greatly exceed the lifetime of LEDs in bullet cameras

LEDs generate heat. The metal fins typically found on the back of an LED illuminator are designed to draw out and dissipate heat away from the electronics of the unit in order to preserve LED life. Generally, with a combined camera / IR unit it is difficult for the housing to be designed in such a way to provide effective heat dissipation which means the LEDs will operate at higher temperatures which will in turn dramatically reduce their operating life. It is the operating temperature of LED more than any other factor which governs the lifetime of the LED.

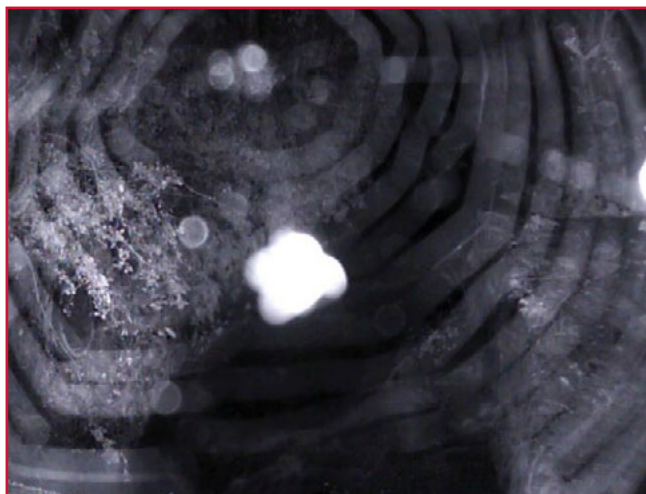
This is a particular problem for longer range bullet cameras, using higher power LEDs which generate more heat.

2) Stand alone illuminators are the only solution for remote monitored sites.

Bullet cameras are not suitable for remote monitored sites as they lead to a high case of false alarms. The heat generated by LEDs is a particular attraction to spiders and various insects. Many Infra-Red illuminators in the field for any length of time will contain some sign of spider webs. This is no problem to the output power of an illuminator and the thickness of the web blocks only a small fraction of the IR power. However, with bullet cameras, any spider web in front of the IR is also a spider web directly in front of the camera. This not only ruins the image but also leads to many false alarms. For this reason, the latest British Standards for remotely monitored CCTV sites (BS8418) states that 'IR illumination should not surround the camera lens on external cameras'.



Unobstructed Field of View with separate LED



Cameras with in-built IR attract spiders

3) Stand alone illuminators lead to better images for the camera.

A familiar problem for bullet cameras and domes with in-built lighting is internal reflection. Light from LEDs inside the camera housing leaks out and bounces around inside the housing, entering the camera lens from an unusual angle. Commonly seen as a ring or 'halo' of LEDs on bullet cameras, this effect ruins the image quality, dramatically reduces distances (as the lens aperture closes to handle the amount of light entering the lens) and can be difficult to correct. For the best results stand alone illuminators are always the best choice.



No Reflection issues with separate LED lighting



Reflection issues using cameras with in-built IR

***Pro-Tip** “IR illumination should not surround the camera lens on external cameras” – British Standard BS8418 for remotely monitored and detector activated CCTV systems.*

LED Lighting	Bullet Cameras
+ Better Quality Images	+ Small size
+ Longer Life	+ Easy install
+ Suitable for remote monitored sites	+ lower cost
- Larger size	- Internal reflection
- Higher cost	- Lower quality images
	- Less reliable
	- Not suitable for remote monitored sites



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