

Are Xenon Burners Still Useful Illuminators?



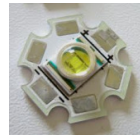
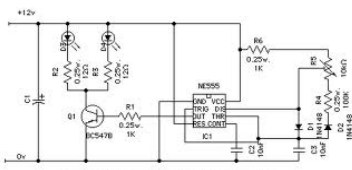



LED versus Xenon - Performance Comparison

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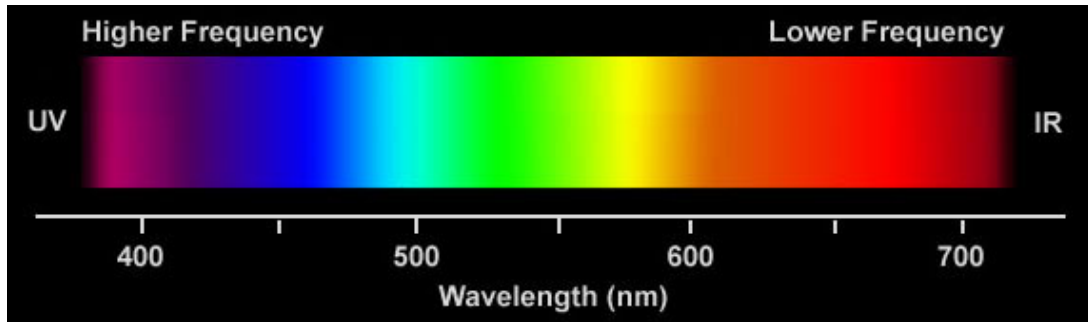
Over the past few years, LED emitters have replaced Xenon burners as more efficient and powerful light sources being able to outshine Xenon lamps by far. Xenon burners are now considered as 'outdated' and threatened to become obsolete. This comparison shall explain some technical and optical differences between the two but also illustrate advantages of Xenon burners and reason why they will remain useful for some time to come.

'Analogue' Xenon burners versus 'digital' LEDs

Manufacturing powerful miniature Xenon burners of high quality is an art mastered by a few manufacturers only. As no electronics are involved, the installation of Xenon burners is relatively simple but the overall performance depends greatly on the precision and finish of the reflector and skills of the installer. Therefore, the supply of reliable Xenon burners and precision machined reflectors are critical for high performance incandescent flashlights. LEDs, on the other hand, have become mass products opening the door to every 'garage shop' to produce LED flashlights of any shape, size but still achieving an acceptable light quality. Like Xenon burners, LEDs can be directly driven by batteries or -more sophisticated- include electronics and circuit boards (drivers), which are also available off-the-shelf. Reflectors might still be made of precision machined aluminium but they are increasingly replaced by prefabricated inexpensive plastic collimators.

| | | | |
|---|---|---|--|
|  |  |  |  |
| <p>Xenon Burner</p> | | <p>LED Emitter</p> | <p>LED Driver</p> |
|  |  |  | |
| <p>Precision Reflector (Pila) For Xenon and LEDs</p> | | <p>Plastic Collimators (e.g. LEDIL as shown) or LEDs only</p> | |

When comparing Xenon with LED lights, it is important to remember that Xenon burners cover a wider range of the light spectrum (close to daylight), whereas LEDs are more monochromatic, emitting a narrower light spectrum with little to no invisible infrared content resulting in higher 'light efficiency'. Also, the colour temperature of high-power Xenon lights is around 3,000 Kelvin making the light appear to the eye slightly yellowish. In contrast, the colour temperature of high end LEDs is around 7,000 Kelvin, which is a very white light and sometimes tending to be slightly bluish because of its blue and ultra-violet (UV) content.



To the eye, the whiter the light the brighter *it appears to be* but this does not mean that it is more 'powerful' or has a better 'throw' than more yellowish lights. At the end, the more yellowish Xenon light might show a better 'light throw' performance than the LED emitter. The more monochromatic 'very white' LED light reduces the eye's contrast perception and makes it difficult for a standard observer to differentiate colour hues! With reduced colour rendition, red, brown, blue and dark green objects illuminated with LED light will appear darker or even black, whereas under Xenon light, the colours appear rather true. In other words, LED light limits the eyes' colour differentiation and recognition, making it difficult to recognize colour shades, contrast, details of objects and background variations, all of which can be critical in some applications, especially in law enforcement and military operations. In addition, standard LEDs emitting visible light have hardly any infrared (IR) content which will be a handicap if users need to mount a standard IR filter (850 nm) on their flashlights in order to turn it into a scene/target illuminator in combination with night-vision equipment.

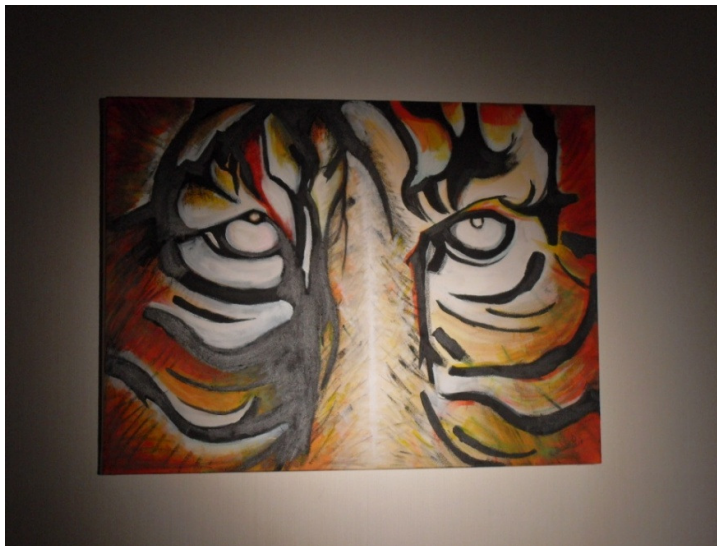
The below pictures show the differences in colour rendition and contrast when illuminated with white LED and Xenon lights.



Original

Distance 3 m (Zoom)

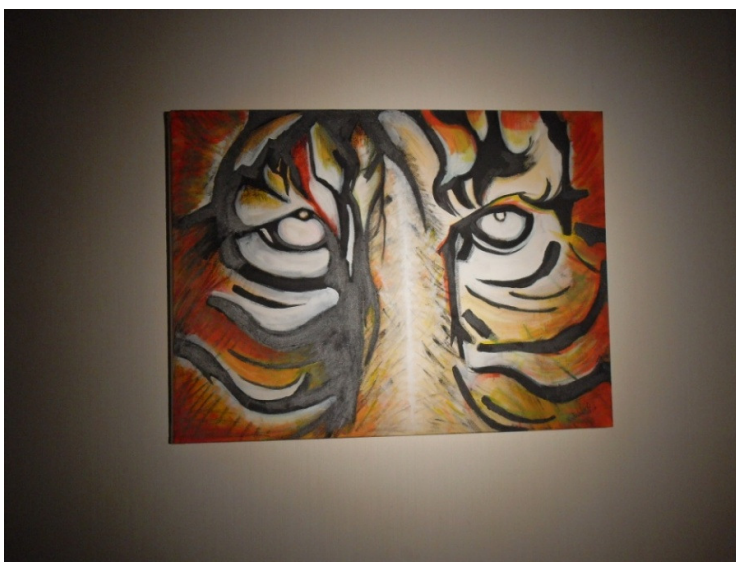
Shutter 1/90 & F 4.4



6V Xenon – 120 Lumen

Distance 3 m (Zoom)

Shutter 1/10 & F 4.8



9V Xenon – 250 Lumen

Distance 3 m (Zoom)

Shutter 1/6 & F 4.4



3W LED – 40 Lumen

Distance 3 m (Zoom)

Shutter 1/10 & F 4.8

(Note: Pila 'Quick-Switch' LED Emitter at 15% light output)



3W LED – 250 Lumen

Distance 3 m (Zoom)

Shutter 1/2 & F 4.8

(Note: Pila 'Quick-Switch' LED Emitter at 100% light output)

“Light Power” – Light Measurement Units

There are many and sometimes confusing light definitions and measurements units, such as Watt, Candela, Lumen, Lux, Luminescence, etc. some of which are explained below. For comparison, this paper focuses mainly on Lumen and Lux as both are understandable to and can easily be verified by laymen.

Lumen [lm] – is the total amount of visible light emitted by a light source in all directions. In simple terms, Lumen may also be described as 'outgoing' light'. However, one must be aware that Lumen do not correspond with 'brightness' as perceived by the human eye!

Lux [lx] – is the light intensity hitting a surface at a distance and the resulting 'light coming into the human eye'.

Candela [cd]: Is the luminous intensity or amount of light (flux) emitted in specific direction by a light source. A common household candle emits light of an intensity of one Candela measured at the distance of 1 metre or 1 foot respectively.

Luminescence [cd/m²] – The intensity of the amount of light (flux) leaving a surface in any given direction measured in Candela per square metre (or square foot –cd/ft²)

Watt [W] – Measures the power energy measures and not the 'light output'! It indicates the energy consumption of the light device.

Colour Temperature [K] – Measurement of the colour of 'white', expressed in 'Kelvin'. Reddish light has a lower and bluish light has a higher colour temperature.

The table below compares Lumen and Lux of Pila[®] tactical and Parat[®] X-treme safety lights. Lux were measured with a calibrated Lux Metre at a defined distance of 1.5 metre.

| | Lumen | Colour Temp. | Lux @ 1.5m |
|-----------------------|--------------|---------------------|-------------------|
| 6V Xenon (Pila GL2) | 120 Lumen | Around 3,000 K | 8,500 Lux |
| 9V Xenon (Pila GL3) | 200 Lumen | Around 3,000 K | 13,500 Lux |
| 3.7V – 9V LED (Pila) | 250 Lumen | Around 7,000+ K | 2,600 Lux |
| 1W Xenon (Parat PX 2) | 10 Lumen | Around 2,500 K | 330 Lux |
| 0.5W LED (Parat PX 2) | 20 Lumen | Around 6,000+ K | 200 Lux |

Notes:

- Pila[®] tactical and Parat[®] X-treme safety lights are manufactured by Permalight (Asia) Co., Ltd. www.pilatorch.com.
- Parat[®] trademark is registered and owned by Parat GmbH, Germany.

From the above table it is evident that higher Lumen ratings do not directly result in higher Lux readings. Optics and physics will explain why the 200 Lumen Xenon burner fares better than the 250 Lumen LED emitter. One of the reasons is the size and form of the actual light emitter. Xenon bulbs include a round filament emitting light in all direction, which is then collected, reflected and emitted by the reflector. The LED is a miniature square dice emitting light in an angular direction. The LED light is focused with the help of a reflector or a collimator. As previously explained, the quality of reflectors respectively collimators are essential for reaching optimal luminance. The main factor to achieve higher Lux readings is that the Xenon burner has a higher Watt rating and so more 'light power' than the LED emitter.

When correlating 'light power' with 'distance' or 'light throw', one must remember that Lux values decrease by inverse square (1/x²) to the distance between the light source and the

illuminated surface because the amount of light will be spread on a wider area. Therefore, the longer the distance, the 'dimmer' the light is perceived by a standard observer. Consequently, Lux ratings of different luminaries must be measured at defined distances.

'Light power' versus 'light efficiency' -in our example, the Watt rating of the 9V Xenon burner (200 Lumen) is around 9 Watt and has, therefore, more *'power'* than the 250 Lumen LED 3 Watt emitter. But as most of the generated *'power'* is lost as heat, the *efficiency rate* of Xenon burner is reduced to 22 Lumen/Watt compared to 82 Lumen/Watt of the LED emitter!

"Light Throw" Compared to Detection, Recognition and Identification (DRI)

'Light throw' is an subjective distance assessment depending primarily on the observer's eyesight and on prevailing environmental factors, such as humidity, rain, fog, temperature but also on the degree of darkness –moonlight, starlight, overcast sky.

The paramount question is: *What can I see at what distance under what conditions?*

It is easier for everyone to visualize a beam 'illuminating a path of 100 metres' than imaging an absolute value of 0.85 Lux, the amount of light captured by the eyes.

To truly assess and compare the performance of different luminaries, *'Detection, Recognition and Identification'* (DRI) of objects at different distances should be taken into consideration. DRI is a terminology, also referred to as 'Johnson Criteria', predicting the performance of electro-optical sensor systems under different *environmental conditions* enabling observers to detect, recognize and identify objects of defined sizes at set ranges.

| | |
|----------------|---|
| Detection | - barely see 'something' |
| Recognition | - discern a car versus a person |
| Identification | - determine the car model, distinguish a woman from a man |

Like electro-optical detectors, the observer's eyes are the human visual sensors designed for scanning surroundings and to detect, recognize and identify different objects. It is apparent that environmental conditions such humidity, temperature, degree of darkness (moon-, starlight, overcast sky) but foremost fog, rain and snow will affect and reduce the "Light Throw" of luminaries greatly. In heavy fog or pouring rain, instead of being able to recognize an object or a person at 100 metres, the same observer will barely be able to detect the target at 20 metres, not to mention the blinding reflection effect of high-power lights.

The below pictures show and compare the 'light throw' of 6V respectively 9V Xenon burners and LED emitters as well as two low Lumen LED and Xenon penlights.

The 12V Xenon 550 Lumen illuminator serves as reference showing the lit-up area for better orientation. Of main interest were distances at which different objects and colours could be recognised and distinguished by the observer respectively captured by the digital camera; e.g. the white (foreground) and black vehicle (middle) and the orange truck at the far end. Readers must be aware that the spectral response of the human eye with its well over 120 million light sensors (rods and cones) is far more light and colour sensitive than a 8.7 Mio. pixels (8.7 Mega Pixel) digital camera CCD sensor. In the test setup, the orange truck illuminated with 9V Xenon (200 Lumen) appeared to the observer's eyes as 'orange' and

under LED light (250 Lumen) as brownish. Yet, under LED light (250 Lumen) the CCD camera sensor captured, with delayed shutter active, the scene to appear much 'brighter' than if flooded with Xenon 200 Lumen, a phenomenon which can partly be attributed to the 'white' sensitivity of the CCD sensor and optics and partly to the narrower LED light beam.

Test conditions:

| | | |
|--------------------------|---|----------------------------------|
| Distance to white car | : | around 50 m |
| Distance to orange truck | : | around 130 m |
| Temperature | : | 30 °C |
| Humidity | : | 78% |
| Ambient light | : | present in background, half-moon |
| Sky | : | Slightly overcast |
| Visibility | : | 10 km |



Reference Picture
12V Xenon 550 Lumen
Shutter 8 & F2.8



6V Xenon – 120 Lumen
Shutter 8 & F2.8



9V Xenon – 200 Lumen
Shutter 8 & F2.8



3W LED -40 Lumen
Shutter 8 & F2.8
(Note: Pila 'Quick-Switch' LED Emitter at 15% light output)



3W LED – 250 Lumen
Shutter 8 & F2.8
(Notes:
- Pila 'Quick-Switch' LED Emitter at 100% light output
- Camera CCD responds to white LED better than to Xenon!)



Penlight
Xenon 10 Lumen
Shutter 8 & F2.8



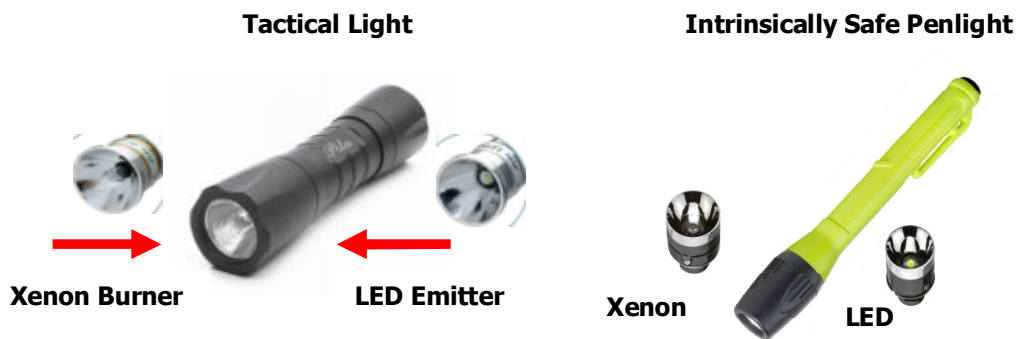
Penlight
0.5W LED 20 Lumen
Note the 'bluish' shift
of the white car.

Reliability (Meantime Between Failure)

The 'light source' in a Xenon bulb is a very thin tungsten filament which will burn and break over time. The tungsten filament is encapsulated in a glass enclosure filled with high-pressure Xenon gas, the actual light medium. Manufacturers of miniature quality Xenon burners state the Meantime Between Failure (MTBF) to be around 25 hours despite some bulbs might last for 100 hours or even longer. LED chips are declared to function for 100,000 hours but such statements are only partly correct. LED chips per se have indeed a very long lifespan but the LED modules' failure rate depend on a number of electronic components, some having a life span limited to a few thousand hours only! Therefore, the MTBF of LED modules depend solely on the weakest electronic component and solder points reducing the "guaranteed" LED MTBF greatly! Cheaper LED flashlights often drive the LED directly from the batteries without using any safety circuit or driver. In this case, LEDs are easily 'overdriven' and become overheated with the result that they will turn blue and fail within a few thousand hours of operation. Yet, it is clear that, under normal conditions, LED emitters will outlive Xenon burners!

Conclusion

The presented comparison between Xenon burners and LED emitters demonstrate that Xenon have still some optical advantages over LED lights, which are: 'Light power', better colour rendition and contrast results. These properties are favoured by numerous individual operators and might be considered as important by specialist personnel, mainly in law enforcement, military and in the engineering field. For these reasons, Xenon burners will retain their operational values for some time to come. However, the above observations and explanations make it apparent that modular flashlights which allow the free interchange of Xenon assemblies and LED emitters present the best light options and optimal operational choice!



General Comparison Between Xenon Burners and LED Emitters

| | Xenon | LED |
|--|--------------------|------------------------|
| Colour identification and contrast perception of target and illuminated surroundings | Very good | Medium to poor |
| Light Power (Lumen/Lux) | Good to Very Good | Medium |
| Efficiency Rate (Lumen/Watt) | Low | High |
| Power Consumption | High | Low |
| Run Time | Short to medium | Long to extended |
| Heat generation | High | Medium to high |
| Light transmission through IR Filter 850 nm | Excellent | Poor |
| Warranted MTBF (valid for Pila [®] tactical flashlights and Parat [®] X-treme safety lights) | Exceeding 25 hours | Exceeding 50,000 hours |

"Though most of us don't hunt, our eyes are still the great monopolists of our senses."
(Diane Ackerman)

Hong Kong, 2011