Peak LED Solutions

Basic LED Flashlights 101

Modern pocket sized Led flashlights in the last few years have undergone a complete revision in design and performance. They are now smaller and more powerful, with longer battery life than incandescent bulb flashlights that most of us have grown up with. The initial cost is higher, but the savings in batteries and expensive bulb replacement quickly makes the high quality LED flashlight a better bargain and overall value.

To determine the correct flashlight for your intended use, several parameters must be considered. This paper will give you the basic information and knowledge required to make the proper choice in your decision of which LED flashlight to buy.

The information contained herein may seem quite long, but we believe that knowledge is power and if you are going to spend quality dollars, spend it wisely. Please be patient and you will be rewarded with a quality LED flashlight that will serve you well for many years.

Basic topics to be covered are:

1. **LED light color**
2. **Output power**
3. **Size and case material**
4. **Battery life**
5. **LED life**

LED LIGHT COLOR

The most useful and popular color of light for a flashlight is a white light output. The white LED produces the full spectrum of colors so that whatever the flashlight is focused on appears in natural colors. The white LED is actually a blue LED that has a coating of phosphors applied similar to that of a fluorescent lamp. Most white 5 mm LED flashlights therefore have a

pronounced bluish cast to them. Peak LED Solutions white LEDs are hand picked from a specialty manufacturer and have a reputation that is the whitest of any major brand LED flashlight. We refer to our exclusive special white LEDs as "Snow" white".

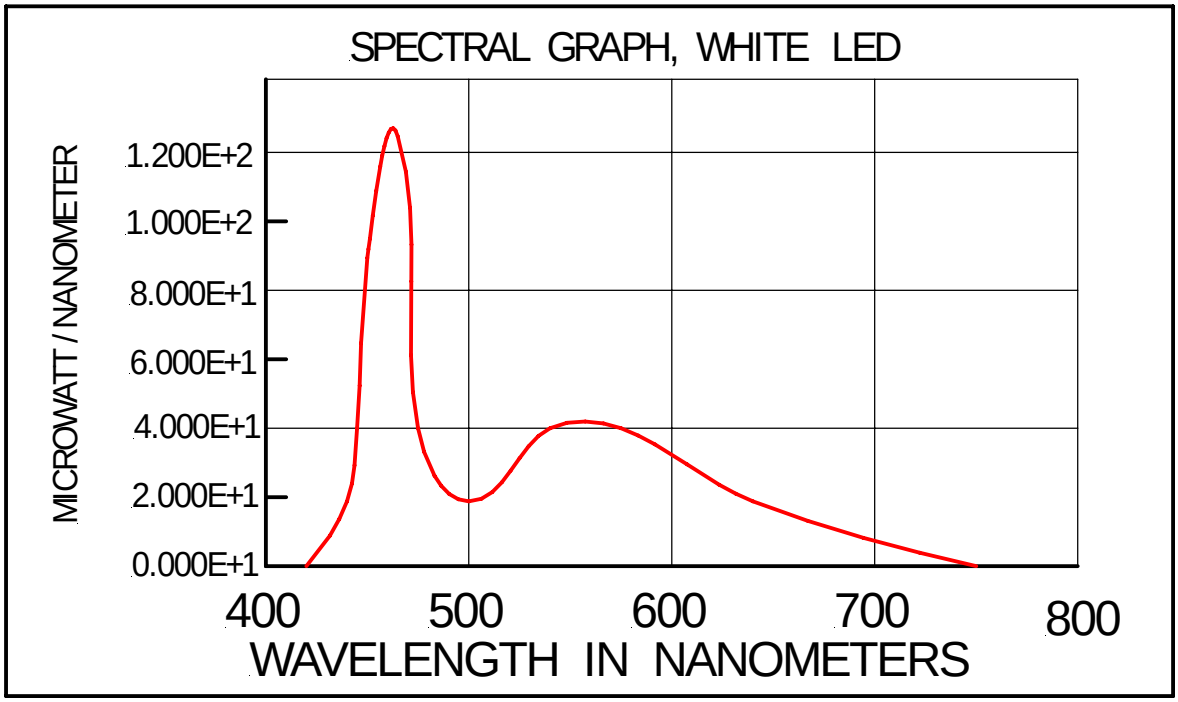


Figure 1

This is the typical output of a white LED, about 6500 degrees Kelvin, generally referred to as cool white. The blue peak, (about 470 nanometers), of the Snow white LED is much lower than that of the typical white LED. The result is an output that has very little blue tint in it, and is closer to the CIE standard of natural sunlight at 5300 degrees Kelvin. Warm white light, such as that from an incandescent house-hold light bulb or a candle, is around 2000 to 3500 degrees Kelvin.

The spectral outputs of the various LED colors are listed as follows.

LED EMISSION WAVELENGTH IN NANOMETERS

SUPER INFRARED	945
INFRARED	880
SUPER RED	639
RED	632
RED ORANGE	624
ORANGE RED	621
YELLOW ORANGE	611
AMBER YELLOW	595
YELLOW	588
GREEN	550
CYAN (AQUA)	505
BLUE	470
VIOLET	440
ULTRA VIOLET (UV) (BLACK LIGHT)	395

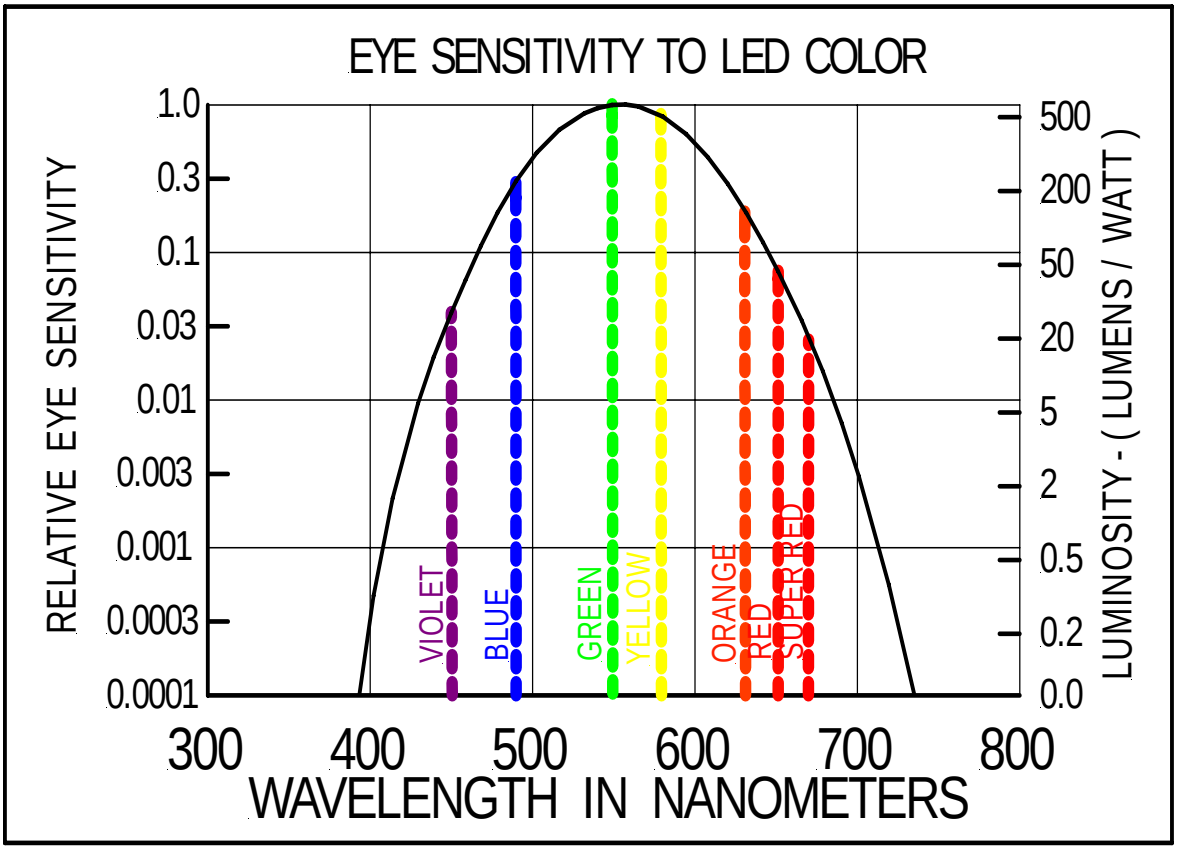


Figure 2

Infrared wavelengths conduct heat and are not visible to the human eye. Wavelengths in the ultra violet range particularly below 365 nanometers can be very dangerous and damaging, be *very* careful when using UV lights.

<u>All high powered light sources must be used with caution to prevent eye damage; they are not toys for children.</u>

The eye is more sensitive to some colors than others. There are three types of color light sensors in the eye. Blue, red, and green cones; rods are low light sensitive. The blue cones actually are blue-green sensitive and the red cones are red-green sensitive. Some colors appear invisible to the human eye although they are very useful under certain conditions.

Any single color LED flashlight will only reflect light from an object that is of the same color. All other objects that are of a different color will appear as a shade of gray to black. Super red is a very useful color because the rods and cones in the eye are not affected by the red light produced by a super red LED flashlight. This means that super red is the only color that does not diminish night vision.

With a red LED flashlight, you can see objects at night with the flashlight on, and still see with it turned off. A white or any other color flashlight used at night will cause night blindness for a short period of time after the light is turned off. An infrared LED flashlight is great for increasing the usefulness of generation 1 or generation 2 type night vision devices.

The ultra violet LED flashlight has a multitude of uses. It can detect the fluorescent response of certain insects such as scorpions. Geologists use them to grade rocks and minerals. Industrial uses include detecting the uniform covering of certain chemical coatings or speed the setting of special epoxies. Police use ultra violet lights during crime scene investigations. Medical personnel use ultra violet flashlights to indicate what needs to be cleaned in aseptic environments.

Health inspectors can determine what has not been cleaned in kitchens and in restrooms. Bankers and cashiers use ultra violet light to detect counterfeit money. Antique dealers determine old glass from modern fakes. And of course there are always fluorescent posters and paints.

<u>WARNING;</u> never look directly into ultra violet light, serious eye damage may occur.

An Amber yellow LED flashlight is the best color choice for penetrating fog, smog, and smoke. Amber light will also show shades of green and shades of red objects. Blue items will appear in shades of gray to black.

Cyan, (Aqua), LEDs will show shades of blue and shades of green objects. Red items will appear in shades of gray to black. Aqua may be the best color for reading aircraft pilot maps at night. Some Cyan, (Aqua), LEDs that are referred to as Cyan, (Aqua), are closer to a traffic green color than a true Cyan.

All colors are useful for back lighting and accent lighting.

LIGHT OUTPUT POWER

There are no standards in measuring the light output of the Light Emitting Diode, (LED), used in flashlights. Each manufacturer will choose the standard that best impresses the buying customer.

Some manufacturers provide output in Candela, others in Lumens or Milliwatts. The Candela measures <u>maximum intensity</u> or brightness at a point. The Lumen is a <u>photometric</u> measure, and Milliwatts are a <u>radiometric</u> measure.

Manufacturers of LEDs list low powered LEDs in MCD units and one watt and higher output LEDs in Lumens.

Candela is the most subjective measurement. It is a measure of output intensity at a point from a source that is

focused as a narrow beam at a distance of one foot, and not the actual total output, (Lumens). The apparent brightness of the beam, measured in Candela, increases or decreases as the angle of the beam changes, even though the power output measured in Lumens remains the same.

The standard industrial unit is the lumen/watt. It measures the total amount of light emitted by a light source per energy input, but doesn't accurately reflect true efficiency of the LED. LEDs are directional light sources. The lumen/watt measures all emissions including the output that is not lighting the object.

The Lumen is the historic measure of light produced by a light source. A candle of specific composition and size emits 1 candlepower. If this candle is placed inside a sphere with a 1-foot radius, 1 Lumen by definition will fall on 1 square foot of the sphere's surface. The total inside surface area of a 1-foot radius sphere is 12.57 square feet; therefore 12.57 Lumens are given off by that candle. One Lumen falling on 1 square foot of a surface produces an illumination of 1 foot-candle, equal to 1 Candela or 1000 MCD. Some manufacturers of LEDs will choose to state output in MCD. 10,000 MCD is equal to 10 Candela, (10 foot-candles or 10 candlepower).

Most LED flashlight manufacturers choose to state the output of their one watt or higher powered lights in Lumens. There are several reasons for using Lumens instead of Candela. The LED manufacturers of one watt or higher devices state the output in Lumens of their LEDs as a typical power output of light under controlled laboratory conditions. Some flashlight manufacturers will generally state that they are using a *30 Lumen output LED*, (as an example), in a particular model flashlight. The <u>actual output</u> of the flashlight depends on how it is being driven by the electronics and may or may not be 30 Lumens. Special expensive laboratory equipment is required to accurately measure output in Lumens. A light meter only measures candlepower. There is no mathematical conversion.

Example, one manufacturer stated that the output of a particular LED flashlight was greater than 40 Lumens, however

when subjected to a laboratory test, one sample turned out to be 17 Lumens. This is not to say that every stated output in Lumens is false, only that using Lumens as a measurement by itself can be misleading and difficult for the buyer to verify. Some manufacturers of LED flashlights will give a high numerical figure to impress the buyer that their flashlight is better than competitors' flashlights.

As a further example, if we drive a one watt LED to an output of 30 Lumens with no beam concentration, in a bare bulb condition, the output is dispersed in a 360 degree circular cone of about 140 degrees of angle. Measuring with a foot-candle light meter at any point within that cone of light at one foot distance will give an average reading of about 11 Candela. If we concentrate that output with a 20 mm diameter 15 degree collimating lens, the light-meter reading will be close to 350 Candela, even though the total Lumen output remains at 30 Lumens. Using the same 30 Lumen output with a correctly profiled 17 mm diameter parabolic reflector with a 10 degree cone concentration, the light-meter reading at a point of maximum intensity will now be closer to 600 Candela. The higher the Candela output means that the object being illuminated will be brighter at a given distance.

A 100 watt incandescent light bulb that has an output of 760 Lumens would not make a good flashlight, nor would a 48 inch long 40 watt fluorescent lamp of over 2000 Lumens.

A statement of Lumens of output does not mean that a flashlight will be useful for a particular application. It may light up a wide area as a flood pattern or a tunnel like spot beam with no side spill. Peak LED Solutions states the output of it's flashlights in Candela that anyone can measure with a low cost light-meter. Our output beam pattern is typically a 10 to 20 degree spot with a wide side spill. We believe that the primary function of a hand-held pocket flashlight is light up a target at a distance while also being able to see surrounding objects.

Light output from a flashlight as seen by the eye is not linear. Twice the light output as measured by a light meter does

not mean the eye sees the lighted object twice as brightly. Also, light intensity decreases as the square of the distance increases. At close distances, (under 5 feet for a pocket LED flashlight), it is difficult to tell the difference between an 18 candela output and a 24 candela output. At a greater distance of 100 feet the same is true with a 500 Candela verses a 600 Candela flashlight.

A test reviewer may give one flashlight a numerical edge over another; however in actual use the difference may not be noticeable. Also that reviewed output will vary from light to light of the same brand by as much as 20 to 30 percent. There is that much tolerance in the light output of the same LEDs made at the same time on the same production line.

It is not possible to accurately judge light output by looking into an LED when it is on. With a fresh battery, an 8 Candela output looks as bright as an 18 Candela output. At 30 to 50 feet distance, the difference can be quite noticeable. Most coin cell, key-chain type flashlights output is 5 to 8 Candelas.

Output power required could be determined by the distance that needs to be illuminated or the light intensity required on the object. Some recommended minimum foot-candle levels for various industrial tasks by the Illuminating Engineering Society are: Assembly, easy 30; difficult 50; medium 100; fine 500; extra fine 1000. Sewing and inspection of clothing 300: Inspection, ordinary 50; difficult 100; highly difficult 150; very difficult 300.

Remember that 1 Candela covers an area of 1 square foot, (144 square inches), at 1 foot distance evenly over the entire area. LED flashlights do not project such a light pattern. Typically, the area covered could be a round circle of light about 4 inches in diameter at 1 foot distance, or approximately 12.5 square inches. The closer the LED flashlight is to the task or object, the better. A 60 Candela light at one foot distance becomes 240 Candela at six inches.

Small, low power LED flashlights are limited to short a distance by the mechanical design of the 5 mm LED itself and the lack of a good reflector or a focusing lens. Depending on conditions, good distance visibility at night is determined by Candela output of the LED and the ability to focus that output.

5 mm LED POCKET FLASHLIGHTS

The 5 mm LED has been around for decades; however it has only recently become powerful enough to be used as a flashlight.

For much of that time the output of an individual LED has been in the 2 to 50 MCD range and the color limited to red. Other colors started to be produced by changing the chemical makeup of the die that generates the light. When they were able to make a blue LED, a phosphorous compound was added to create white light. The die size was increased as was the efficiency of the die and now a 5 mm LED can output as much as 32,000 MCD at a standard current input of 20 mA. Over driving the LED with higher current levels can produce an even higher MCD output.

About 7 years ago a new 5 mm LED flashlight, (by CMG), started a revolution with a single LED single AA battery flashlight and a simple electronic voltage boost circuit. The output was about 8 Candela, not much better than small coin cell key ring lights of today. The first good pocket LED flashlight, (by Arc), followed 3 years later with a smaller AAA battery and an output of about 22 Candela. The current versions of the single LED output are in the 40 to 43 Candela range. This has been achieved due to advancements in the process of manufacturing the LED and over-driving the LED. The 5 mm LED has just about reached its performance limits and we cannot expect much more improvement from this form factor.

The limiting parameter is the inability to remove heat generated within the LED die, because the die is surrounded by a clear epoxy shell. Yes, LEDs do produce heat within the die. An incandescent bulb with a glass envelope produces light by

heating up a filament wire, and using a reflector to throw the heat and the light out the front of the flashlight. An LED is very efficient in converting electrical energy into light producing photons; the problem is getting those photons out of the die. About 15% of the generated light leaves the die; the rest is reabsorbed within the die and converted into heat.

The critical area within the die is called the junction. The higher the junction temperature the less efficient the LED is in converting electricity into light. High heat or the inability of the LED to get rid of excessive heat shortens the life of the LED. Because of heat buildup within the die, most 5 mm LEDs have a maximum current limit of 30 to 50 mA.

The performance of the following list of 5 mm LED flashlights is subjective and the distance is limited only to the good apparent illumination of the object at the distance given. All flashlights listed use white LEDs. All Peak LED Solutions 5 mm flashlights in the sample use our exclusive "Snow" white LEDs. All multiple LED flashlights listed are made by Peak LED Solutions and outputs are a total of light from each LED.

FLASHLIGHT TYPE	OUTPUT	DISTANCE
1 LED coin cell key-chain type	5.5 Candela	12 feet
1 LED competitor AA battery	24 Candela	20 feet
1 LED Peak Solutions AAA HP	33 Candela	24 feet
1 LED Peak Solutions AAA UP	40 Candela	29 feet
1 LED competitor AAA	43 Candela	31 feet
3 LED Peak Solutions AAA HP	85 Candela	48 feet
3 LED Peak Solutions AAA UP	115 Candela	60 feet
7 LED Peak Solutions AA HP	155 Candela	88 feet
7 LED Peak Solutions CR123 UP	210 Candela	114 feet

In the pervious list; HP is High Power and UP is Ultra Power output level. AAA, AA, and CR123 are battery types.

Multiple LED lights are lower in measured Candela output because each led is not focused at the same spot. Therefore the beam pattern, or hot spot, is wider and the maximum intensity at

a point of measure is slightly lower. An LED flashlight producing 40 Candela per LED times 7 LEDs equals 280 Candela in real output. Even though the actual measurement averages 210 Candela using a light-meters small area sensor, the real output of all LEDs is still a total of 280 Candela or 280,000 MCD.

HIGH PERFORMANCE LIGHT EMITTING DIODES

Within the last several years there has been a revolution in the energy efficiency and compactness of the LED light source that rivals the output of incandescent or florescent lamps. Much of this is due to the mechanical redesign to remove heat generated by the die. Instead of a 30 to 50 mA current limit of the 5 mm LED, (1/8 of a watt), the new designs can handle up to 1400 mA per die at the same voltage, (almost 5 watts).

The first flashlight to use this type of LED, (the LS, again by Arc), was a compact one watt single CR123A battery design, with an output of about 265 Candela, (265,000 MCD), and a battery run time of just under 2 hours. This flashlight started a new revolution that exceeded the output of the old standard 2 D cell incandescent bulb flashlight in a smaller form factor that could be put into a pants pocket.

The latest version of this flashlight, (the Caribbean), made by Peak is smaller, and using the latest in electronics and LED design, can produce as much as 900 Candela, (900,000 MCD), using the same single CR123A battery, as the original. The Caribbean uses a 3 watt LED being driven at 1 ½ watts. This flashlight can produce an even higher output, however good design practice limits the practical output by the ability of the case size to remove heat generated by the LED. A higher output flashlight in this size would generate so much heat that the flashlight would be hard to hold onto. The high heat would also affect the life of the LED, electronics, and the battery.

Some low cost imported High Performance LED flashlights do not follow good design practices and either use poor heat transfer or insulate the heat from the outside case.

The result is the flashlight is cool on the outside to touch but damaging to the LED and electronics. This drastically shortens the life of the flashlight from tens of thousands of hours to several hundred or less. Initial low cost may not always be cheapest overall.

Peak LED Solutions produces slightly larger single battery pocket sized LED flashlights with output power up to 3 ¾ watts, or about 2,000 Candela, (2,000,000 MCD). That is enough power to light up the side of a building at 300 feet, (91 meters).

The 5 mm LED has just about reached its design limits while the High Performance LED has a long way to go. This does not mean that you should wait for the next LED output level, since that may be several years from now. A quality, correctly designed High Performance LED flashlight is currently your best overall value.

Peak produces High Performance LED flashlights in power levels from 50 Candela to over 2000 Candela. The lower power versions are more battery efficient than the same output in 5 mm LED flashlights. The initial cost of the High Performance LED flashlight is slightly higher than the 5 mm lights, but that will be quickly made up by lower per hour operating cost.

STYLE, SIZE AND CASE MATERIAL

Style or design will determine the overall use and function of the LED flashlight and its versatility.

The physical size of the flashlight will determine how it will be carried, when it will be carried, and what type battery will be used.

The type of case material and finish will determine the maintenance required over the life of the flashlight. Maintenance includes cleaning and lubricating the threads, the o-ring seals, and cleaning battery contacts.

STYLE AND DESIGN

Style and design include the number of LEDs used, single or double LED headed designs, or a special design for industrial, military or commercial applications.

Peak offers head designs using the standard popular 5 millimeter LED in 1, 3, and 7 LED combinations. The greater the requirement for light output dictates the number of LEDs incorporated in each head design. An increase in the number of LEDs determines the diameter of the flashlight and the type of battery used. Battery type and size must be matched with the increased current draw in heads with multiple LEDs to maintain useful battery life.

Several of these designs incorporate a single LED or multiple LED heads on each end of a single body, with separate batteries powering each LED head independently. The advantage of this style is that you can have two different colors or two different outputs of LED lights with you at the same time in only one flashlight. Using two batteries, one can be exhausted and the other one will still power either LED head. The two colors can be in any combination, white and red, white and UV or red and UV. Those are the most requested combinations. Other combinations are available. A multiple LED head on one end and a single LED head on the opposite end is very useful when less light or when a longer battery life is sometimes needed. This type of flashlight is also available with an LED head on one end and a watertight cap on the other end. The empty compartment may be used to store a spare battery or anything else that will fit inside. Matches, fishhooks, a small knife, or medications are only a sample of what can be carried with you, when you carry a Peak Solutions double end LED flashlight. A water tight cap may also be used with a spare separate battery compartment.

Peak has incorporated into the design several unique features not available in most competitive flashlights. In most single head LED designs, our key-ring can be unscrewed, allowing the flashlight to be removed from your keys and used

without encumbrances. This allows the flashlight to stand on end, pointing upwards and used as an area light. In addition, it may be attached to other devices using a standard 3/8 ths inch by 24 pitch thread. Peak offers a handy magnetic and/or spring clamp assembly, with a stay in place movable gooseneck arm. This allows Peak flashlights to be used as portable task lights wherever needed for hands free uses. This is a very handy feature when working under a car or on a craft project where extra light is needed.

Another feature of the removable key-ring design is the removable spring loaded negative battery contact. This feature allows for easy cleaning of this important area. Dirty contact surfaces on the battery or the flashlight surfaces can decrease the light output or no light output at all.

By removing both the key-ring adapter and the negative contact, a specially designed optional momentary switch may be installed. This does not change the normal on-off operation of the flashlight; it just adds convenience of one handed operation.

SIZE IS VERY IMPORTANT

If the size of a flashlight is too large, you may not always carry it with you.

Peak LED Solutions has gone to great efforts to provide in combination, the smallest practical case size with the most light output, battery life, versatility, quality, and value of any flashlight manufacturer. In our engineering design staffs opinion,Peak has leaped ahead of all other LED flashlight manufacturers in size versus light output and run time using the 5 mm LED and the High Performance LEDs.

5 mm LED FLASHLIGHTS

Using a single AAA battery, the one or three LED head version is only .50 inches (12.7 mm) in diameter and 3.10 inches

(78.7 mm) long. The three LED design produces up to three times the light output and allows for longer battery life than some similar sized single LED, single AAA battery competitive designs.

The AA single battery design from Peak with the one or seven LED head options, offers up to six times the light output of some single LED competitive flashlights. At 11/16 ths inch (17.8 mm) diameter and only 3.3 inches (83.8 mm) long, this powerful light will still fit in most pants pockets. Rechargeable, lithium, and standard AA alkaline batteries are available anywhere to make this 5 mm Peak LED Solutions flashlight your first choice for work or play.

The CR123 pocket light is the most versatile of the entire Peak 5 mm designs. Available in a single LED head model or with an unrivaled seven LED head, the single lithium battery provides many hours of constant stable light. At ¾ inch (19 mm) in diameter and only 2.7 inches (68.5 mm) long, it is shorter than most AAA or AA battery designs while producing up to nine times their light output. The CR123 style also comes in a doubled end design of 5.7 inches (144.7 mm) in length. This size, while a little long for a pants pocket, fits nicely into the belt holsters made for the popular 2 AA flashlights.

All standard head designs are available either with a single LED or with multiple LEDs. Light output and battery life will determine the size, style and number of LEDs required.

The "N" cell flashlight is available in three body styles with one or three LED head designs. The low current capacity of the battery design results in a lower overall light output. The relative low light output is useful where less light is required, such as in the cockpit of an aircraft at night. The smallest "N" cell flashlight is only 9/16 ths inch (14.3 mm) in diameter and 2.05 inches (52 mm) long, the perfect key-chain flashlight. The double end "N" cell flashlight is of the same diameter and 5 inches (126 mm) long. A special flashlight using two "N" cells for a three volt drive is 5 inches (126 mm) long. The advantage

of the three volt design is a flatter discharge curve and more battery life for low light level requirements.

HIGH PERFORMANCE LED FLASHLIGHTS

The battery case and head designs of the High Performance LED flashlights by Peak LED Solutions incorporate many of the same features of the 5 mm styles, plus more battery and power output choices within each line. In some designs, a single head style can be interchanged with as many as nine different battery compartments, and with different types of and different numbers of batteries. This allows a single flashlight to be tailored to the requirements of a particular application without the expense of having to buy different flashlights.

Many flashlights in these lines may also be ordered with different power output levels. As an example, the Pacific line can be had with any output level from 50 Candela for an extremely long run time with a single AA battery, to about 1000 Candela using two AAA batteries.

Head designs incorporate a replaceable, unbreakable, scratch resistant polycarbonate plastic lens to protect the LED. The internal electronic cavity is filled with electronic grade epoxy for maximum shock and water resistance. The LED is mounted on a special heat sink to transfer generated heat away from the LED to the case to be dispersed to the atmosphere. O-rings seal all other areas that may be exposed to moisture. The positive battery contact on the head is 24 carat gold plated and not lead solder as most other competitors use.

FLASHLIGHT CASE MATERIAL

Peak offers five different material choices. Each material has advantages and disadvantages. Peak does not make flashlights with plastic cases, only with high quality metals designed to last for years of hard usage.

Using aircraft quality aluminum with electronic grade chemical conversion coating on the inside and hard type III

anodize on the outside, this is the lightest of the metals used in the manufacture of Peak flashlights. The anodized coating gives the flashlight years of good looks with normal wear. The only disadvantage of all aluminum flashlights is that they require that the threads be cleaned and well greased with silicone periodically. Also, battery contacts must be kept clean in ensure good electrical conduction.

Solid brass is the recommended metal for flashlights by Peak LED Solutions. It has a very nice feel to it, a feel of quality, lost to a generation of cheap plastic flashlights. Very little maintenance is required of our brass LED flashlights. A small amount of silicone grease to the threads every now and then is all the maintenance needed. Brass does weigh more than aluminum; however that small increase in weight is not noticeable when carried in a pocket or a purse. Brass also has a softer surface than the anodized aluminum and will show very small nicks and scratches sooner than the anodized surface. The anodizing can wear through at the corners and edges and show the aluminum surface at those areas. The threads in brass will normally outlast the aluminum for years of trouble free service.

The third version of the Peaks' case material is in reality the same solid brass as above, except that it is chrome plated and then plated with a layer of 24 carat gold inside and out. The reason for gold plating is corrosion resistance, electrical conductivity, and it looks great. It comes with a small black velvet pocket protector to maintain its beautiful appearance for years.

The most rugged flashlight material used by Peak LED Solutions is a non-magnetic type 300 stainless steel. This very low maintenance flashlight can be used in almost any environment and in almost any application. Stainless is almost as heavy as brass and does not come with any knurling on the battery case. This makes it easier to clean without the knurl trapping dirt or septic contamination in the grooves. Stainless steel can be used in any clean room application, in the medical field, and in damp conditions without worry of corrosion. Again,

the weight factor of stainless or brass is very small, a factor of importance only to hikers.

Limited runs of pure titanium in certain Peak flashlight lines are done for those that require a lighter corrosion resistant flashlight. The material is very expensive and the machining is tougher than stainless steel on tooling. Pure titanium is softer than stainless steel and will scratch easer.

NOTE: Never use solvents of any kind on any LED flashlight as the exposed plastic lens or the LED itself may be damaged. Warm water and mild soap are OK. Silicone grease is the preferred lubricant and can be picked up at most hardware stores. A small amount will last for many years.

BATTERY LIFE

Batteries are available in two basic types, primary or secondary. A primary battery is any battery that can be used only once. A secondary battery is any battery that can be recharged and used more than once.

Primary batteries feature a higher current density, (more capacity), and a higher voltage than most secondary batteries. Except for some lithium formula batteries, many secondary batteries maintain their voltage levels during discharge better than primaries. The internal mechanical design of small primary and non-alkaline designs limit their ability to provide large amounts of current in continuous high drain applications.

Brand name batteries will usually last slightly longer in service than less expensive brands and normally have a better resistance to leaking. However, all manufactured items will have that occasional bad battery that slips through. There is always some variation in battery output even in the same manufactured lot. The following list is an average summary of battery capacity.

PRIMARY TYPE DISPOSABLE BATTERIES

SIZE		CAPACITY	SIZE		CAPACITY
HEAVY DUTY ZINC			**ALKALINE**		
N	1.5 VOLT	460 mA	N	1.5 VOLT	720 mA
AAA		570 mA	AAA		1150 mA
AA		1100 mA	AA		2850 mA
C		2900 mA	C		8350 mA
D		6500 mA	D		18000 mA
SUPER ALKALINE			**LITHIUM**		
AAA	1.5 VOLT	1450 mA	AA	1.5 VOLT	2600 mA
AA		3350 mA	1/3 N	3 VOLT	170 mA
C		10500 mA	CR2		750 mA
D		22500 mA	CR123		1400 mA

SECONDARY TYPE RECHARGEABLE BATTERIES

NICKEL CADMIUM			NICKEL METAL HYDRIDE		
AAA	1.2 VOLT	300 mA	AAA	1.2 VOLT	850 mA
AA		850 mA	AA		2600 mA
C		1100 mA	C		3500 mA
D		1400 mA	D		8500 mA

LITHIUM-ION RECHARGEABLE BATTERIES

These batteries are still evolving, originally used in cell phones and laptop computers, they are now being offered in cylindrical forms. They are typically described by a number as to their size. A 10280 size is 10 mm in diameter and 28 mm in length, about 2/3 the size of a standard AAA battery.

They have no memory effect as to the discharge/recharge cycle as is the case with nickel cadmium batteries. They do not like to be fully discharged and would prefer to be charged quite

often. They can normally take 500 plus full recharges when properly used. If a full discharge takes 45 minutes for a RCR-123 size battery as in the Peak LED Solutions' Rainier flashlight, the life of the battery is extended by charging before 45 minutes of usage. When used 10 minutes and then charged, 20 minutes and charged, and 15 minutes and charged, that would equal one full 45 minute discharge/charge cycle even though it has been in the charger three times. A pair of batteries for the Rainier may last as long as 20 years. A real quality value with a very powerful small pocket sized LED flashlight.

Most LI-Ion batteries have a built in protection circuit to prevent total discharge. Some are even regulated as to limit the maximum output voltage. Output current capacity of non-regulated batteries is very good and can power some of the most powerful LED flashlights. The LI-Ion battery also has a lower self-discharge rate than the other rechargeable batteries. Discharge rates should be limited to two times capacity.

6.0 VOLT DISPOSABLE LANTERN BATTERIES

SQUARE CARBON ZINC	**8000 mA**
SQUARE ALKALINE	**26000 mA**
RECTANGULAR CARBON ZINC	**15700 mA**
RECTANGULAR ALKALINE	**52000 mA**

We recommend the usage of nickel metal hydride batteries over that of nickel cadmium batteries. NiMH batteries have superior energy density, better cycle life, little or no memory effect, and very good discharge characteristics. These are the best value for high drain or daily battery usage in most LED flashlights. They are also a very good choice in flashlights that cannot handle the high voltage output of the Li-Ion batteries. The biggest problem with NiMH batteries is that they self-discharge about one-half to one percent of their capacity per day even when not used.

Lithium batteries are a superior power source for primary type batteries. They have in combination the highest energy density and voltage, longest service life, lowest self-discharge

and widest temperature range of any primary battery commercially available. A flatter and stable discharge curve means that the light output is more constant throughout the life of the battery. They are also the most expensive. This is the best battery choice for occasional usage. Some competitors LED flashlights cannot use Lithium batteries because the higher voltage can damage their LEDs or electronics. This is not a problem with any Peak LED Solutions flashlight. Our electronics is designed to handle overload conditions and keep working.

Alkaline batteries are the most popular because of their cost versus service, power, and availability. Most testing of LED flashlights is done with alkaline batteries. As rated from the capacity chart above, a good quality alkaline battery will give the longest continuous use time of any battery listed. The major disadvantage is the steeper discharge curves as compared to NiMH or Lithium and they are much heavier. As the battery is used the output voltage drops faster and therefore the total light output also diminishes quicker. Output current capacity is also less because of the internal mechanical design of the battery.

Carbon zinc batteries should only be used as a last resort. Their capacity in most high drain, high power LED flashlight applications do not justify their cost.

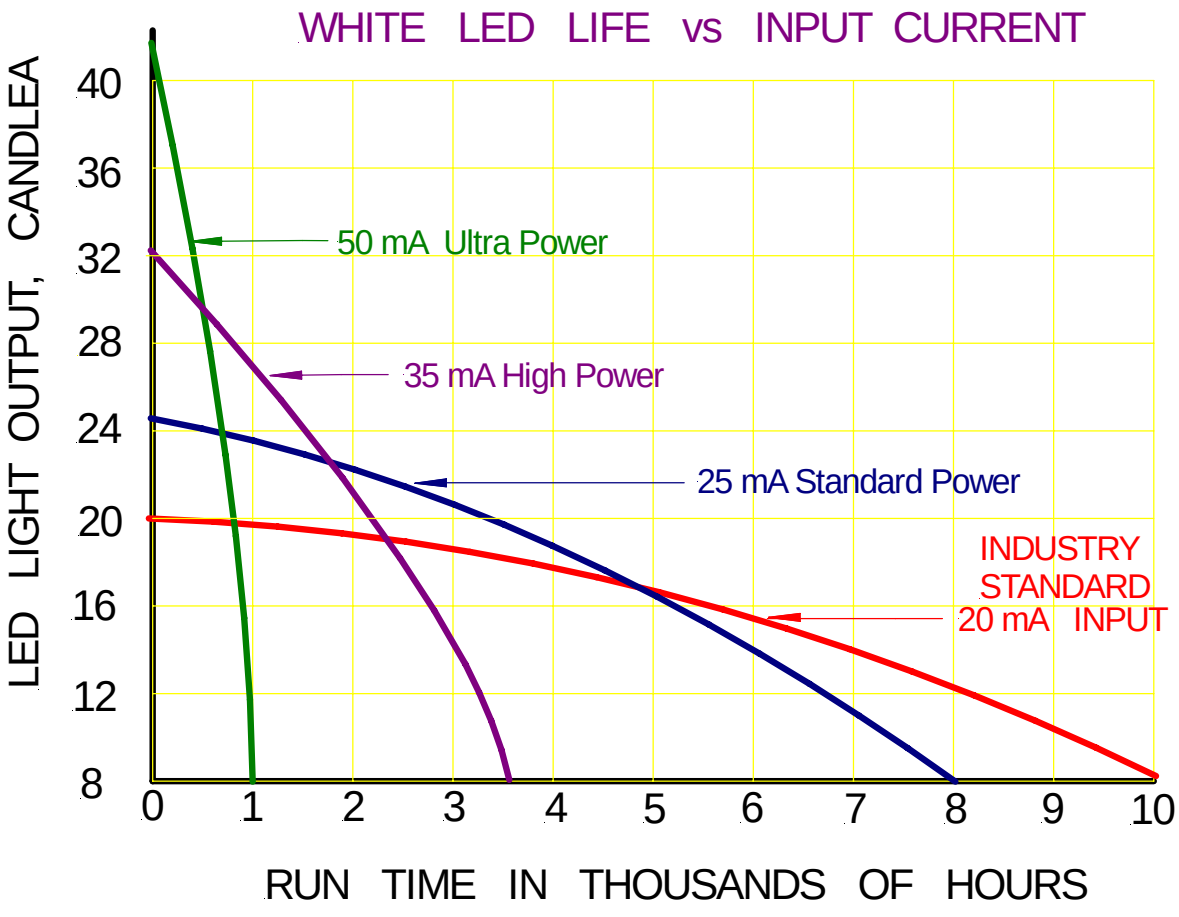
LED LIFE

We all have heard that LEDs last forever, use almost no power, and are virtually indestructible.

Most LED's do have a very long life, up to 100,000 hours under the controlled conditions specified by the manufacturers. However, they do start to lose initial brightness as soon as they are used. For most, it is a very, very slow curve. Most manufacturers rate the 5mm LEDs at a standard current of 20 mA at rated voltage on their data information sheets. They also publish maximum limits for the normal operation of the LED. Like any light source, as the voltage and current are increased, the light output also increases and the life of the bulb or LED

decreases. For most LEDs used in flashlights, this is not a problem.

White, 5 mm LEDs present a different situation. They are made with blue LEDs and a coating of a phosphorous compound(s). While the LED itself will last for a very long time, the phosphors start to degrade much faster. Most white LEDs have a mean phosphorous life of about 10,000 hours at a rated current of 20 mA. A number of manufacturers of LED flashlights do not make the distinction of LED life and white light output. They still claim 100,000 hours. They did not intend to mislead their customers; they just assume that there is no difference between white LEDs and normal colored LEDs. The LED itself will still work for tens of thousands of hours but it just will not make good white light. It will grow dim similar to that on the ends of a fluorescent lamp.



As can be seen from the chart above, the white light output verses LED life are related to the input current that drives the LED. The times are from a constant current and voltage source. LED life driven by a battery will tend to be longer depending upon the discharge characteristics of the battery and how often the battery is changed. The industry standard of 20 mA drive current is what many LED manufacturers recommend as their test current on their data sheets. Some manufacturers of LED flashlights drive the LED far beyond the LED manufacturers maximum published limits to increase the light output of the flashlight.

The maximum limit set by the manufacturer of the 5 mm white LEDs that Peak uses is 30 mA. Peak has chosen (by testing and evaluating empirical data) to drive its standard output LEDs at 25 to 27 mA. This gives the flashlight owner the best compromise of light output, battery life, and LED life. To increase the light output of the flashlight, Peak increases the number of LEDs in many of its designs.

Using the most advanced power/battery management integrated circuit design available; Peaks' LED flashlights outperform the competitions flashlights in many areas. The single LED AAA flashlight produces very good light output while running over 30 hours of battery time verses an observed 10 hours for some competitors. In addition, after several 1000 hours of run time, the Peak flashlight produces more light than some competitive flashlights due to their faster LED degradation. The Peak 3 LED AAA flashlight produces more light output than some other 5 mm single LED flashlights, yet it has been observed to run hours longer from the same size AAA battery.

Peak LED Solutions also overdrives the LEDs in the High Power and Ultra Power versions of the same flashlights. As can be seen in the above LED life chart, this has a negative effect on the life of the flashlight. In real life applications it is not as bad as it first appears. Most people use their flashlight for less than 5 minutes per day, about 30 hours per year, and some users may

not change a AAA battery in a year's time. The higher power output verses several years of usage are acceptable.

If more LED life is required for constant duty as in a work environment, then the Peaks' Baltic Sea flashlight using a three watt LED being driven at a fraction of a watt, will give over 20,000 hours of actual high performance output. 5 hours per day for 240 days per year will equal better than 16 years of constant usage.

Test #	# 1	# 2	# 3	# 4	# 5	# 6
Brand	Peak Pacific	Brand "F"	Peak 3 LED	Brand "A"	Peak 1 LED	Brand "M-S"
Type	High Power	LED LOP	High Power	LED 4P	Ultra Power	Incandescent Lamp
Battery	1 x AAA	1 x AAA	1 x AAA	1 x AAA	1 x AAA	1 x AAA
Start	221 fc	156 fc	96 fc	43 fc	40 fc	131 fc
30 min	200	93	61	35	33	59
1 HOUR	194	73	50	32	29	43
2 HOURS	182	22	40	28	25	30
3 HOURS	101	1.1	35	25	23	22
4 HOURS	85	0.3	32	23	22	13
5 HOURS	73		27	22	20	0
6 HOURS	51		25	21	19	
7 HOURS	36		22	19	18	
8 HOURS	26		19	13	17	
9 HOURS	19		16	0.7	16	
10 HOURS	14		13	0.3	15	
12 HOURS	8		8		13	FOCUSED
14 HOURS	5		5		10	FOR
16 HOURS	3		3		8	MAXIMUM
18 HOURS	2		2		6	INTENSITY
24 HOURS	0.6		0.8		3.1	

This chart shows the battery life and power output in Candela for single LED, (test #3 is a three LED flashlight), and incandescent lamp flashlights using a <u>single</u> AAA alkaline battery. The above chart is comprised of information from observations made by Peaks own testing. The data in the chart is empirical and repeatable. Three of the lights tested are from

Peak LED Solutions and three from competitors. The very low cost incandescent lamp pocket flashlights are very power hungry, have a short bulb life, and the filament inside the bulb can break when dropped. Field stripping and replacing the burned out bulb in the dark is always interesting.

All Peak LED flashlights are designed to produce the most light output and battery run time of any LED flashlight manufacturer. Combined with the highest quality electronics, mechanical parts and design features, any of the Peak LED Solutions flashlights are your best overall value.

The Peak Solutions LED flashlights are designed and manufactured and assembled in Phoenix, Arizona, U.S.A.

We take personal pride in manufacturing the best LED flashlights in the world. Please contact us at sales@peakledsolutions.net or 1-877-881-7325

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