Light a Candle...

by Kerry McIntyre

This month's Shop Talk will focus on the confusing new technology of aircraft landing and taxi lights. Over the last five years there has been much innovation in aircraft lighting. Your tried and true GE 4509 lamp is no longer your only option. Incandescent filament type bulbs are becoming outdated and HID or LEDs may be a better choice the next time your plane needs a new bright light.

To understand the marketing claims by the different manufactures, one must understand the language used when it comes to lighting. First some definition of terms:

CANDELA: This is the modern term for radiated light and is roughly the same as the obsolete term, candlepower. It can be considered the radiated power of a light source. In common usage, a 100 watt light bulb generates roughly 120 candelas. It is a measure of how much energy a light source is releasing. It does not define what happens to the light once it leaves the radiating surface. Its definition specifies a monochromatic light source and so becomes a difficult measurement of common light sources. This difficulty resulted in standard definitions for the term candlepower changing over time. By the most recent standard, one candlepower equals 0.981 candela. In spite of candela or candlepower not being the best measure of a light, manufacturers use it often. But understand that a light with a well designed reflector and lens may actually be brighter than one with a higher candela rating.

LUMENS: This is the candela multiplied by the solid angle, i.e., how much light is contained in a given area. Included in the definition is how the light is perceived by the human eye so lumen is a more useful unit of measurement than candela. A one-candela light source emitting in all directions uniformly (a sphere) produces exactly 4π (pi) lumens. If half the sphere is blocked by a totally absorbing material that system would radiate 2π lumens, but the intensity of the light would still be one-candela. If the light were 100% reflected instead of blocked, the system would be back to 4π lumens. Trust me I am trying to keep it simple.

LUX: This is the measurement of perceived light on a surface (illuminance). One lux is the amount of illumination on a surface one meter from a one candela source. Foot-candle is the non-metric unit of lux. Think of lux as being a meter-candle. One foot-candle is approximately 10.8 lux. What is meant by perceived light is that the response of the eye is considered when measuring illuminance. For example, the lux measurement on a surface one meter from an infra-red light source (say 1,000 candelas) would be zero as the infra-red light is not perceived by our eyes. A photographer's light meter measures foot-candles or lux.

COLOR TEMPERATURE: Another item to consider is the perceived color of the light projected by the light source. It is defined as the temperature of a black-body radiator, measured in kelvins (Celsius degrees above absolute zero. So, water melts/freezes at about 273 K (0° C)). This is called color temperature. The human eye perceives some colors better than others. This is the luminosity function of the light source. An example of this is the color red is not as perceivable to the human eye as yellow or green or white. White, of course, is not a specific color but a spread of colors across the visible spectrum. Therefore a red lamp of equal candela will not be as effective as a white light of the same radiance. As color temperature increases colors shift away from red light to yellow to blue. A GE 4509 light powered at its nominal voltage (13 volts), will appear to be a yellow-white color as it runs a color temperature around 2900K. A typical HID (high intensity discharge) system will run around 4200K, and a typical LED will run around 6500K. The LED lamp will look blue-white compared to the HID which will look bright white. The sun's surface (photosphere) is 5778K color temperature, but the light is affected by the Earth's atmosphere. Blue light is scattered (blue sky) and clouds absorb the lower frequencies. That is why an overcast day tends to look blue (~7000K). Color perception is also affected by the intensity of light reaching the eye. Color perception fades at low light levels. An example of this phenomenon is moonlight. The color temperature of the moon is about 4000K and should, therefore, look more yellow than sunlight, but the light level is so low that we can't perceive this color shift as the eye's sensitivity to reds and yellows decreases faster than to blue and violet. Most human eyes are optimized for maximum response to yellow-green at daylight light levels.

Back to marketing claims. As can be deduced from the above definitions, comparisons of a lamp's candela rating are questionable as this characteristic is of dubious value. Lumens are of some value as this can tell us how much potential usable light a lamp produces. The key word here is potential. For instance, if the lamp produces a very narrow beam with no dispersal, then only what is directly in the beam can be seen. Think of how impractical a landing light with the dispersal pattern of a laser beam would be. What is really needed to determine the relative effectiveness of a lamp is to measure the lux values at various points and distances in the area of interest for a particular flight operation, i.e., landing or taxiing.

Currently approved GE landing and taxi lights date back to before the FAA was formed. Back in 1925 Warren Grimes was contracted by Henry Ford to engineer and install the first landing light on the first production Tri-Motor. Back then, the USA Department of War was the lead agency for aviation as the CAA would not be formed until 1938; so, no TSO or PMA or STC were in effect. These certifications became mandated when the FAA was established in 1958. With this info one can see why there is little to no guidance in the FARs concerning landing or taxi lights.

Let's explain the different types of lights on the market and how they work and if they can be legally installed in your certified aircraft. The first light is the tried and true incandescent GE4509 (13 volt) or 4596 (28 volt) both are a PAR36 (parabolic aluminized reflector, 36/8" diameter) style lamps rated at 100 watts (4509) and 250 watts (4596). The other common lamps are the GE4522 (13 volt) and the 4553 (28 volt), both are PAR46 style lamps and are rated at 250 watts. All of these lamps use a glowing filament in front of a reflector with a spot beam lens, designed to illuminate an object in the distance. One disadvantage of this type of light is the glowing filament is easy to break when subjected to vibration or shock. We all know that airplanes have plenty of both and therefore these types of lamps typically have a short life span and may not be there to work for you when you need them. Most of these lamps are rated at 25 hour life span, in the best of conditions.

A GE4509 will put out about 110,000 candela at 13 volts under ideal conditions and will draw around 8 amps continuously. The lamp will run about 110 degrees Fahrenheit depending on air flow around the lamp. When the glowing filament sags in front of the focal point of the reflector the lumen output will decrease as the light source is no longer at the focal point of the reflector.

If your aircraft came with one of these FAA standard lights from the factory, a log book entry by the pilot is required under FAR 43 appendix A to replace an inoperative landing or taxi light with the same type of light. The other types of lights we will talk about (LED and HID) are not so easy to legally install and return to service. To do that you must have one of the following:

1. A production drawing from the airframe manufacturer for the specific aircraft model and serial number.
2. An STC for the specific model and serial number with PMA approval for the components.
3. A 337 field approval for specific model and serial number, signed in block 3 by a FSDO.

The latest innovation in lighting is LEDs (light emitting diodes). LEDs are not new but the technology driving them into the aircraft landing and taxi light position is advancing and getting better. Individual LEDs are grouped together to produce a light similar in size and quality to the PAR36 or PAR46 lights airplanes currently use. The LEDs are much more robust when compared to a filament type bulb and are expected to last 5000 hours or more. Some advertisements I have read state their LED lamp is a direct replacement for your certified aircraft. But wait just a minute! As of this article date, only Wheelen has a PMA approval; one of the requirements to retrofit your certified aircraft. Whelen uses an STC through Floats Alaska LLC (STC SA02212AK) as a legal way to install their Parmetheus PAR36 size lamp (they do not currently offer a PAR46 lamp), but you must still complete an FAA 337 to legally install their lamp in your certified aircraft.

One concern when assuming that a LED lamp is a direct replacement for a PAR type is that there is a heat sink on the back of LED lamps. The size of that heat sink is relative to the power of the light and may become a factor for some installations. Consider carefully the manufacturer's dimension specifications for the light being installed. Be sure that there will be adequate cooling and physical space.

AeroLEDs is another company that states you can just install their lamp on your certified aircraft but they have no STC or PMA to allow you to complete this job correctly (per the FARs) at this time. Both companies make claims of candela output but because the shape of the reflector and lens is so important these numbers are difficult to compare to each other or to an incandescent or HID system.

AeroLEDs lamp specifications do include lumens output. They have a built-in safety feature that they they will dim to prevent thermal runaway. With an LED lamp if one or two LEDs happen to fail the remaining LEDs will continue to work. It is still unclear as to how many LEDs can be out before one must change out the lamp but when you consider how robust the LED lamp is this may be a moot point.

Whelen offers a taxi lamp (40 degree beam spread) and a landing light (10 degree beam spread) while AeroLEDs offers their Sunspot 36HX (landing) and 36LX (taxi) lamps. AeroLEDs also offer a PAR46 lamp in taxi or landing configurations. AeroLEDs is working with Northern aviation on STC approval and will work on PMA approval after the STC is obtained. The Whelen PAR36 lamps are $325 and the same size AeroLED lamp is $299 for the 36LX and $399 for the more powerfull 36HX.. The Wheelen lamp comes with a plastic lens cover that if damaged can be replaced in the field. All LEDs are polarity sensitive. Typically, the LED lamps will draw 2 - 4 amps as compared to 8 amps for the GE lamp.

The LED lamps are meant to compete with the GE lamps and not to compete with the HID (high intensity discharge) systems that we will talk about next. You will see this in the lux readings we collected during testing.

HID uses a lamp that creates an arc at its tip so there is no glowing element to break. The arc is created by a high voltage power supply (ballast) located within 6 feet of the lamp The ballast is powered by the existing aircraft landing light circuit so no special interface wiring is required. The ballast cable (to the lamp) is a shielded high voltage multi-conductor wire assembly with special waterproof connectors on each end. An igniter is part of the lamp so these PAR36 and PAR46 lamps are typically deeper than a GE lamp. LoPresti, Precise Flite and XeVision all manufacture HID aircraft landing and taxi light systems.

A typical 35 watt HID system will produce about 3 times the lumens of a GE4509 at about one third the current draw. The HID color temperature runs 4200-4500 K, but the lamp runs cooler than the GE lamp and even some of the LEDs. The ballast typically run about 110° F so there is no cooling problem with the HID even thought the light output is 3 times that of the GE

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lamp. XeVision and LoPresti also offer higher ballast output units that up the candela to as high as 750,000! This is way too much light for taxing between hangers or around other aircraft but is remarkable for landing or daytime high-congested areas. Remember See & Be Seen? High power landing lights aren't just for night time.

The HID lamps will also last a long time and are not damaged easily by vibration or overheating. One can expect a typical HID bulb to last 1500 hours or more. When we talk about the life of the LED or HID lamps we are talking about changing out your aircraft engine before changing out the lamp!

Unfortunately not all HID systems are the same. Even though the wattage and output are comparable the lens and reflector are what control the projection and focus of the light beam This makes it very difficult to compare apples to apples when it comes to landing lights.

All of the HID manufactures offer some type of pulse system that can be installed as a remote unit wired into the existing landing or taxi light electrical system. XeVision offers a dimmable ballast for those of you that use the same lamp for taxi and landing. Their ballast is rated at 50 watts and can be dimmed down to 35 watts for taxi operations.

LoPresti and Precise Flite have multiple STC and PMA approvals while XeVision has 2 STC approvals and expects PMA approval sometime in 2011. The Precise Flite and XeVision systems are priced around $600 for a single 35 watt system and LoPresti systems start around $950. The HID systems are double the price of the LED systems but they are not just for night time operations. Because they are so bright one can be seen a long way away. Their brightness draws the eye to them, especially when a pulsing circuit is added. The LED and GE lamps pale in comparison with the HID systems.

At this point in the article we have learned the terminology and design features and have come to the conclusion that the LED systems are designed to compete with the GE lamps and not the awesome power of the HID systems. We have also come to the realization that the design of the reflector and lens are probably 75 percent of the efficiency of the lamp and just comparing candela or lumens is not the whole story.

First we must understand what the purpose of a landing light is and what we expect out of our landing light. At night, on the glide slope at 50 feet above the end of the runway, your landing point is about 955 feet ahead of you. This is the point your airplane should touch down and is the area you need to have illuminated. If you are flying a helicopter this view is probably unimportant to you as you will not touch down on the runway at 70 MPH. In a helicopter a movable spot light is more important. However, both the helicopter and the fixed wing aircraft share a common need during the day and that is to be seen by other aircraft to avoid a midair collision. Let me try to better explain the See & Be Seen scenario as it happened to a friend of mine years ago.

My friend takes off in his Piper Twin Comanche at 1630 one sunny December day leaving Corona airport headed for Fullerton airport due west (about 25 miles) into the setting sun. At the same time a Bonanza is flying from John Wayne airport heading to Chino airport due north (about 25 miles) at the same altitude with the sun blinding his left eye the whole way. The Bonanza collides with the Piper removing the Comanche's vertical fin and rudder, putting it into a flat spin. Both pilots die in the accident.

If either aircraft had an HID light operating, the other pilot should have been able to see it through the glare of the sun or against the background of the Southern California mountains. There are a lot of maybes in that statement but without the HID system the final outcome was assured to be bad. The recent collision between a helicopter and a Cessna in Virginia is another possible scenario where HID lighting might have saved the day. The midair over the Hudson river in 2009.... The list goes on.

AVWeb recently did a side by side comparison of some of these lights but not all of them, in their video "Are LED lights bright enough?" I wanted to see all three types of lights in a side-by-side comparison. With a GE4509 and a Whelen LED landing light, I set off for XeVision's office at the Ogden, Utah airport to get some hard numbers and perceived opinions.. My quest was to determine if the cost of the advanced system was justified: the LED system over the incandescent, the HID over both the LED and incandescent. It is inevitable that all three systems be compared against each other but as stated earlier it is not fair to compare LED to HID.

Our tests were done with a 12 volt aircraft battery and a power supply to maintain the battery condition. We made a target out of a black mat about 3 foot by 2 foot tall. A white stripe was added in the center in a vertical position as to simulate the runway view. None of the materials were reflective.

We decided on three types of tests to simulate a typical GA airplane scenario at night. As you look at the table below you will see that the first scenario is with the target at 100 feet. We show the lux reading for each light as it is focused on the target, and we show the perceived color of the light, along with the shape of the beam. What was really interesting was the fact that even though the lux reading was very low on the LED we could actually see the target better than the view with the GE lamp. I think this is because of the color temperature difference between the two. Both HID lights were so bright it was as if it was daytime and not night and the lux readings show this. We chose to only test spot beams (landing lights) even though the LED and HID manufactures offer a spread beam taxi lamp systems because most small aircraft use the same GE spot beam for taxi and landing, just aimed differently.

The next test shows the lux readings of each light at 10 and 20 feet offset from the centerline with the light still aimed on the center of the target. The purpose of this test was to show how much light was available to keep the pilot from turning off the runway and into the giggle weeds instead of onto a taxiway. The perceived view was just as the the lux meter numbers show. This is where a spread beam taxi light would really come in handy as it would offer higher lux readings off centerline.

Our last test was a typical landing scenario at night. At 955 feet, the 100 watt GE lamp barely illuminated the target. The LED light did not illuminate the target enough to make it out visually and the lux meter readings reflect both lights poor ability to complete this job. Both HID lights illuminated the target well and the lux meter readings verify this.

LANDING LIGHT TYPE & PART NO.	100' PERCEIVED COLOR & SHAPE	100' LUX METER READING	100' LUX METER READING OFF CENTERLINE	955' PERCEIVED VIEW	955' LUX METER READING
INCANDESCENT GE4509	YELLOW-WHITE ELONGATED FOOTBALL	82	2 @ 10' 0 @ 20'	BARELY SEE TARGET	LESS THAN 4
LED WHEELEN 0771424-10	BLUE-WHITE SPOT WITH FOOTBALL SIDES	30	4 @ 10' 0 @ 20'	CAN'T SEE TARGET	LESS THAN 1
HID XEVISION XV4D-35 (WATT)	(BRIGHT) WHITE SPOT WITH FOOTBALL SIDES	385	18 @ 10' 3 @ 20'	CAN FOCUS ON TARGET	9
HID XEVISION XV4D-50 (WATT)	(BRIGHT) WHITE SPOT WITH FOOTBALL SIDES	560	30 @ 10' 3 @ 20'	EASILY SEE TARGET	12

After seeing and reviewing the testing and results I have come to some interesting conclusions. The Wheelen LED will make a suitable replacement for your taxi light with its robust ability to take vibration. For taxiing, there appears to be no sacrifice in lighting capabilities. If money is no object, even if you don't fly at night, HID taxi and landing light systems are the way to go if only for the added "See & Be Seen" insurance. No pilot would be disappointed with a HID lighting system in the taxi or landing position, and the extra cost can be justified with the safety factor of flying in congested areas during day light hours. The Wheelen LED light can be a more affordable option in the taxi position and the extra cost can be justified by never again changing another broken filament GE lamp. When you figure the time involved to change the lamp and the fact that it may not work when you get to your destination and the aggravation this creates the Wheelen LED may be the hot ticket. For airplanes using the same light for taxi and landing, I would recommend the XeVision dimmable ballast HID system when it is approved sometime this year.

Finally, one additional advantage to LED or HID systems is the lower current draw needed. Installing a light system that draws less current when turned on without sacrificing lux capabilities leaves more capacity in your electrical system for the operation of other systems and provides less stress on the entire electrical system. This is especially important for airplanes that still have generators. With low power requirements and long life, running the "daytime anti-collision light system" continually when in congested airspace is a good practice. Airline procedures require some bright lights on below 10,000'. Southwest Airlines' 737s have been equipped with wig-wag landing lights for decades. Additionally, several studies have indicated that pulsing bright lights on aircraft may lower incidents of bird strikes.

I would like to express my thanks to Wheelen, Precise Flight, David LoPresti and in Ogden, Dan Blumel and the good folks at XeVision for answering all my questions and educating me on this subject. The light technologies mentioned in this article are relatively new to aircraft and new FAA approvals occur often. Check with the manufacturers to determine if your aircraft is approved for a specific installation.

In conclusion, this has been a very enlightening article to write and try to explain the terminology and technology of this subject. As always, if you have a question about this article you can call my aircraft repair shop at 307-789-6866 or e-mail me at shoptalk@knr-inc.com. Until the next Shop Talk, enjoy flying your Mooney.