

Preco 7600 series LED rotating beacon design considerations

By Dean Wilkinson, 6/29/2006

The Preco 7600 LED beacon is the first rotating safety beacon that utilizes LED technology. Historically, safety lighting started out with rotating sealed beam halogen beacons. Later, products based on rotating parabolic mirror halogen rotator and Xenon strobe flash lamp beacons were introduced. The Xenon flash lamp beacons offered a reliability improvement over halogen rotators because the Xenon flash lamps tended to have longer operating life than halogen bulbs, and the brushed DC motors with their associated gearing limit the life of the rotating beacons.

Xenon strobe beacons did not displace rotating halogen beacons completely from the marketplace despite their improved reliability. This is because the rotating beacons tend to be preferred by operators over strobe beacons for a number of reasons. The rotating beacons offer better visibility in fog allowing observers to determine the location of the beacon since the beam sweeping through the fog is visible and can be used to locate the source. Conversely, strobe beacons send light in all directions at once, and tend to light up the fog bank over a large area making it difficult to pinpoint the source. The FAA requires that the beacons used to help pilots locate an airport be rotating beacons to ensure that they are clearly visible to pilots in all weather conditions. Rotating beacons also provide a flash that is less abrupt with a flash duration in the 10's of milliseconds. Xenon flash lamps produce flashes with high peak energy lasting only about a tenth of a

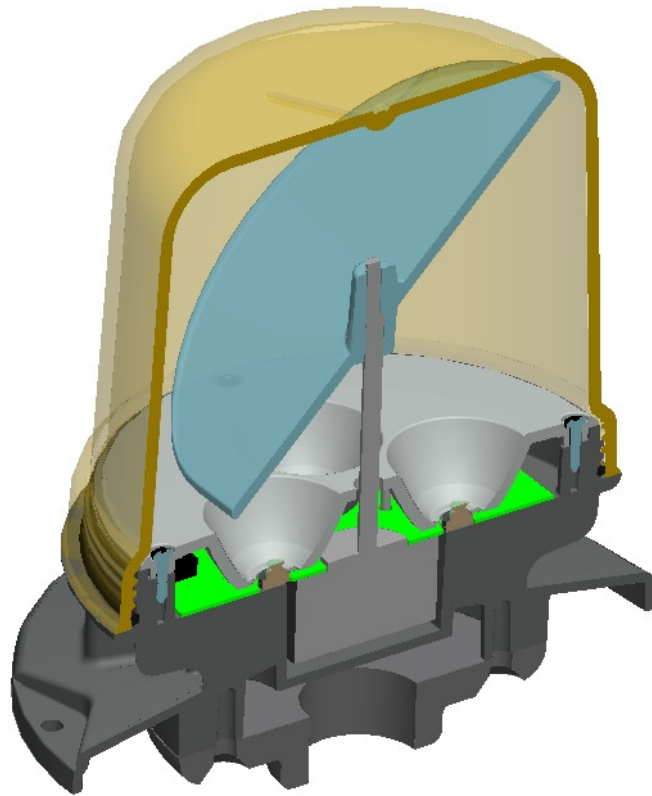
millisecond. Xenon flash lamps also produce a burst of radio frequency (RF) radiation that can interfere with radios while the halogen rotators do not.

With the advent of high power, high brightness LEDs in recent years, a number of suppliers have started to manufacture LED based safety beacons. All of the products currently on the market are strobe style beacons which utilize Fresnel lenses like those used in Xenon flash lamp beacons. The LEDs offer an advantage over the Xenon flash lamp beacons in operating life and reliability in vibration, and the overall product current draw is typically less than half that of a Xenon beacon. Additionally, the LEDs do not require the use of a costly and life limiting flash capacitor.

The flash patterns of LED strobe style beacons are made up of long duration flashes with much lower peak intensity than the flashes from a Xenon flash lamp. The peak flash intensity of LED strobe beacons also tends to be substantially lower than those found in rotating halogen beacons. Consequently, even if the LED beacon has the same integrated flash energy as a Xenon or halogen beacon, it will not be as visible in bright sunlight due to a lower peak contrast ratio. The peak contrast is the ratio between the peak flash intensity and the intensity of the sunlight reflecting off the beacon and its surroundings. Visibility in bright sunlight tends to be a weakness of LED strobe style beacons. For equal integrated flash energy, LED beacons that pulse their LEDs to higher peak level for shorter durations will be more visible in sunlight than those that utilize longer pulse durations due to a higher peak contrast. The latest draft of the SAE requirements for safety beacons is attempting to address the unique performance

requirements of LED beacons while also including older technologies by changing from per-flash requirements to total optical power delivered in a minute and adding a requirement for a minimum peak flash energy level.

Preco has chosen to implement an LED based safety beacon based on the original rotating beacon style in the form of the 7600 series beacon. The primary reason for selecting this style is to provide a beacon that has all of the advantages of the traditional halogen rotator combined with the higher reliability and lower current draw that can be achieved with LED technology. By creating a rotating beam of light from the LEDs, the 7600 series achieves the required integrated flash energy with a higher peak flash intensity than that of strobe style LED beacons. In addition to overcoming the efficiency and reliability shortcomings of the halogen bulb by using LEDs, the 7600 series beacon avoids the problems found in brushed DC motors and associated gear drive by using a direct-drive stepper motor. A direct-drive stepper motor has much greater reliability than a brushed DC motor and gear assembly because the only moving parts are the shaft and rotor which are supported by two sealed bearings. The stepper motor uses magnetic induction to rotate the rotor and shaft so there are no electrical brushes or other contacts that can wear out. The only parts of the motor that can wear out are the ball-bearings which are long life components.



The design of the 7600 series beacon places the LEDs on the base of the unit. The light from the LEDs is collimated into a beam that shines straight up from the base. A 45° mirror is mounted to the shaft of the direct-drive stepper motor and rotated to intercept the beam and rotate it around in a 360° circle to sweep the beam much like a halogen rotator. The mirror is rotated to produce either 90 flashes per minute or 120 flashes per minute depending on the configuration of the circuit board.

The 7600 series uses four 3-Watt Lumileds Luxeon III side emitting LEDs that have an integral heat slug. The heat slugs are thermally bonded directly to the aluminum base to maximize the transfer of heat from the LEDs. The aluminum base is designed with air pockets and cooling fins directly beneath each LED to provide an efficient transfer of heat from the base to the ambient air. This thermal design keeps the LED junction temperatures from rising by more than 35C to 40C above the ambient air temperature in still air, and the LED temperature rise is even lower in the presence of moving air. This is important since LED brightness is lower at high temperatures than it is at lower temperatures, and long term exposure to junction temperatures above 80C causes their nominal brightness to begin to drop 1000's of hours sooner than their 100,000 hour rated life. The maximum junction temperature that the LEDs can survive is 130C.

The light emitted by the side-emitting Luxeon III LED is captured by a parabolic reflector. Each LED has its own parabolic reflector, and all four parabolic reflectors are contained in a single polycarbonate plastic reflector assembly. The reflectors collimate the light into narrow beams with most of the light falling inside of a 10° cone. The polycarbonate reflector is covered with a thin film of highly reflective aluminum encapsulated by a clear coating which protects the aluminum film from corrosion. The 45° rotating mirror is also made of polycarbonate plastic with an aluminum reflective coating.

The circuit board assembly that contains the power supply and control circuitry that drives the LEDs and stepper motor are mounted on top of the base beneath the parabolic

reflector assembly. The circuit board assembly is screwed down to the base, and the stepper motor is attached to the circuit board with bolts and nuts. The stepper motor is bonded to the base with a potting compound that holds it rigidly in place to prevent shock and vibration from moving the motor and flexing the circuit board. This ensures that the assembly is rugged enough to withstand high levels of vibration and shock without damage to any of the electronic components.

The outer cover is made of clear polycarbonate plastic that is screwed to the base with threads and sealed with an O-ring. A clear lens was selected to maximize transmission of the light from the LEDs. Colored lenses are not necessary since the LEDs emit the desired SAE colors without filtering, and color filter pigments would reduce the transmission of light through the outer cover. The cover is coated with a clear material that provides a hard scratch resistant and UV blocking barrier. This hard coat protects the lens from the elements and extends its life by keeping it transparent and maintains its appearance. It also makes it easier to clean dust and deposits from the lens.

The LEDs are available in Red, Green, Blue, Amber, and White and their chromaticity coordinates meet SAE requirements for each color. The Red and Blue LEDs provide sufficient brightness to meet SAE J845 Class 1 requirements. While there is no SAE specification for Green, the Green LED version of the beacon would qualify as a Class 1 beacon using the requirements applied to Red and Blue. White and Amber meet SAE J845 Class 2 requirement currently, but with forecast improvements to the LED efficiencies and temperature performance, Preco anticipates that Class 1 White and

Amber beacons could be available sometime in 2007. Amber LEDs currently have the most temperature dependent brightness characteristics. For ambient temperatures above 0C the Amber 7600 series beacon will meet SAE Class 2 requirements, but when the ambient temperature is below 0C, it will meet SAE Class 1 requirements. The Amber LEDs emit about 4 times as much light at -40C as they do at room temperature. This means that snow removal equipment will benefit from the highest Amber beacon brightness levels, which is beneficial since snow and frost can partially obscure safety beacons.

The top of the 45° mirror is reflective, so when the sun is higher than 45° above the horizon, there will be two angles in the plane of rotation in which an additional white flash will be seen due to a reflection of the sun. When the sun is directly overhead, this sun flash will be seen in all directions in the plane of rotation. Preco is investigating the use of color filters on the top surface of the 45° mirror to filter this sun flash to match the color of the LEDs. While the sun flash is not available at all times of the day and at all angles, it will appear when the sun is providing its most direct and intense illumination. This further enhances the visibility and attention getting properties of the 7600 series beacon.