Lumen Depreciation and Lamp Mortality Analysis
gHID

Two of the most notable benefits to the GHID solution are the decreased lumen depreciation and the extended lamp life. This document is provided to better explain these benefits through a technical explanation of how they are calculated and proven.

Ballast Types

Most common HID ballasts are referred to as 'magnetic', being an iron-core transformer that operates at 60Hz, power line frequency, and drive the bulb at the same frequency. Magnetic ballasts use a capacitor and/or igniter, are generally heavy, run hot by design, are sometimes noisy making an audible 'hum' when in use and tend to lose their electromagnetic strength over time. The latter is known, typically, as degradation and is an unavoidable result in the magnetic field the ballast uses to operate the lamp.

Other electronic ballasts offer some improvements over magnetic, but still operate at relatively low drive frequencies (between 60Hz, power line frequency, and 50kHz). They are able to offer a “softstrike” and “dormant-mode” through the use of a microprocessor. The microprocessor generates extreme heat (similar to a computer, which requires a cooling fan) and therefore these other electronic ballasts attempt dissipating this additional heat through “fins” on the exterior of the ballast. Even with the “fins” design, major failures due to overheating have occurred with other electronic ballasts, which have jeopardized their success in the industry. Additionally, they typically come with upper temperature limits which exclude them from most exterior applications as well as those utilizing a sealed fixture design such as hazardous locations and other adverse conditions.

GHID is an electronic ballast operating at over 100,000Hz bulb drive frequency. GHID is able to offer all of its benefits through Genesys Systems’ patented NON-microprocessor design. Due to the absence of a microprocessor, GHID is able to operate at a much lower temperature creating a reliable environment for the electronic components. Additionally, all GHID ballasts are completely sealed with an epoxy potting material and together the entire design system has gained GHID UL® certification for “inside” or “outside” the fixture.

gHID Technology Overview

Lamp Re-strike Sequence

The GHID ballast design provides a control system strike sequence that is significantly slower and less often than other ballasts on the market. It takes into consideration any existing lamp conditions such as being hot or being dormant for some time. An initial cold lamp strike will generally occur approximately 30 seconds after power is applied, and a hot lamp re-strike is much quicker than other magnetic and electronic ballast technologies. So, the lamp is struck less, thus reducing wear on striking electrodes.

Strike/Run Mode Sensing

The GHID ballast uses a soft-strike sequence and through its 'run condition sensor' that disables the striking process and prevents unnecessary lamp striking. As the lamp begins its warm-up and run, sensors within the ballast determine the lamp’s state as being within acceptable limits. In the case of a shorted lamp (or sometimes referred to as a false-run) the run mode is terminated and is restarted from a “re-strike condition” sequence.

Strike, Lamp Warm-up Process

The GHID ballast begins the strike sequence with, a 'gas excitation sequence’ being applied to the lamp for approximately 1.5 Seconds. Being of less voltage than a strike, it actually enhances the lamp condition for striking by causing motion in the gases. This is by inducing a small electromagnetic field between the striking electrodes which helps the lamp gases to blend. These gases often segregate when cooled and this separation often cause the need for additional strikes between the electrodes to effectively strike the lamp, thus reducing electrode life when using other ballast technologies.

CONCEPTS

• Lumen: the radiation, or "luminous flux", which comes from a lamp is measured in lumens (lm). This quantity allows for the fact that the sensation of "light" experienced by the human eye/brain system depends on the wavelength of the radiation entering the eye. The same amount of energy at the opposite ends of the spectrum - red and blue - produces less sensation than in the middle (yellow/green). At the peak of sensitivity one watt of radiated electromagnetic power is equivalent to 683 lumens.

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CONCEPTS

• Illuminance: the flux from a luminaire travels in various directions through space until it strikes a surface. The amount of light falling per unit area of the surface is called the illuminance, and is measured in lumens per square meter or lux (lx). If the luminaire is at reasonable distance from the surface it can be regarded as a point source, and the illuminance (lx) on a surface perpendicular to the intensity direction is simply the intensity I (cd) divided by the square of the distance D (m). This is sufficiently accurate to calculate the illuminance of vertical objects lit by headlamps.

Strike Voltage Incline Process

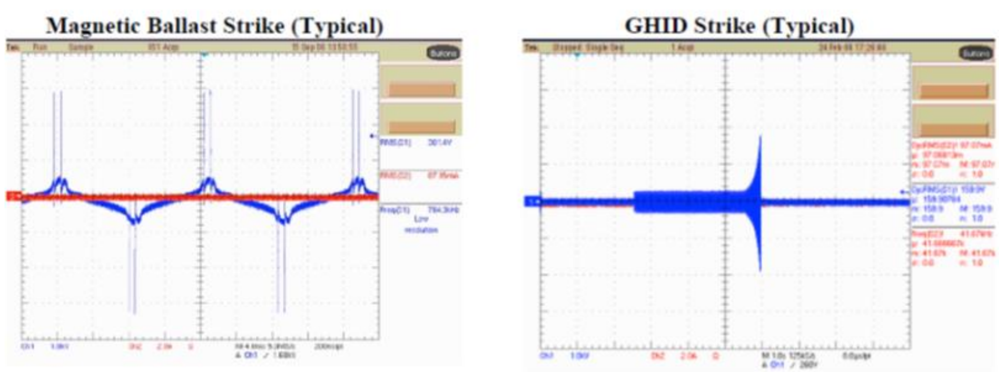
The gHID ballast follows the 'gas excitation sequence' with it's patented 'lamp strike sequence' for a period of 0.5 seconds. During this time, the voltage is slowly increased, so that when the lamp accepts the strike voltage (creating a successful arc), it is at a 'minimum' acceptable level for the lamp and not in excess. In the case of a hot lamp, the voltage ramp is terminated at the ANSI maximum level so that excessive electrode wear is eliminated. When an effective strike occurs in the lamp, the ballast drive power is restricted to prevent the unnecessary lamp abuse caused overpower while in a run condition.

Lamp Lumen Depreciation and Early Life Failure

Lamp Striking

A primary factor affecting the decline in the lumen output of a lamp over time is the harsh environment that a magnetic ballast creates through the effect of its electromagnetic transformer. Magnetic ballasts will strike a lamp at every 60Hz voltage peak, which means there are 7200 strikes per minute until the lamp ignites. The gHID ballast soft strike only strikes a lamp a maximum of 2 times per minute. The strike sequences have been captured in Figure 1.1 below.

Figure 1.1: Strike Sequence



The ineffective and unnecessary re-striking of magnetic ballasts (as shown above in Figure 1.1) greatly deteriorates the electrodes. Evidence of this additional abuse is shown in Figure 1.2 below. Each of these electrodes have driven lamps for 4,000 hours in a 12 hours on and 12 hours off sequence to emulate typical dusk until dawn operation.

Figure 1.2: Electrode Deterioration – 4,000 Hrs of Typical Lamp Operation

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Not only does the re-striking of magnetic ballasts (and some other electronic ballasts) deteriorate the electrodes, but it also uses unnecessary power, thereby greatly reducing the overall efficiency and life of the system. It is important to note, though unrelated to lamp-life, that when a lamp does fail, a magnetic ballast is unable to sense that the lamp has failed and will repeatedly try to re-strike the lamp for an indefinite amount of time or until failure of the ballast transformer or capacitor/igniter. This early life failure due to overheating can melt the magnetic ballast coil insulation and therefore shorting the coil and eliminating its ability to create its electromagnetic field and to operate the lamp.

Through the diagnostics available within the GHID ballast, it is able to determine that the lamp has failed and enters a dormant, 'non-striking' state, not using unnecessary energy and not causing any unnecessary harm to the ballast or components. This helps to extend the life the GHID ballast significantly.

Blackening

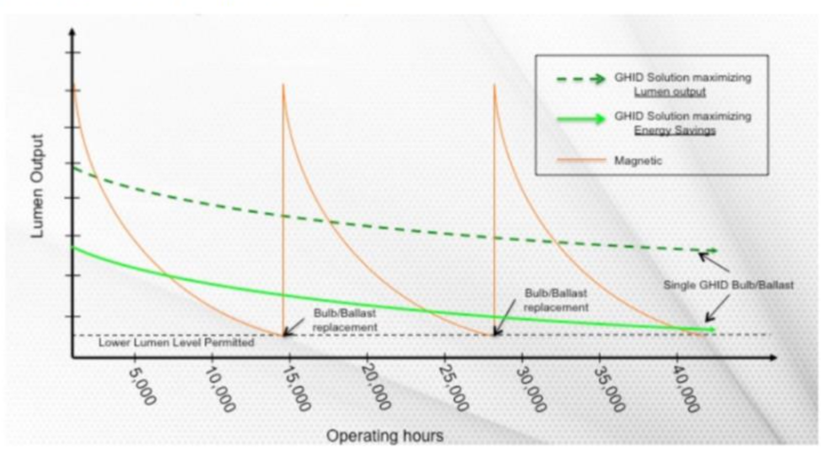
Another cause of poor mean lumen output in HID bulbs is due to the adherence of tungsten to the walls of the internal gas chamber or 'envelope', which can obscure the light output. Figure 2.1 below depicts the difference in blackening of a MH lamp after 8000 hours of operation.

Figure 2.1: Lamp Blackening

Results

Due to the soft strike ability of the Genesys Systems' gHID ballast products, as well as the onboard diagnostics and optimization capabilities, produces improved lamp performance and reduces system degradation as depicted in Figure 3.1 below.

Figure 3.1: GHID Lamp Degradation



NOTES

The gHID technology described in this report is graphed above to demonstrate the contrast of standard HID system degradation when comparing a magnetic ballasted application to the gHID system solution. The increased energy efficiency of the gHID solution coupled with the increased overall system longevity of both bulb and ballast significantly reduces fixture maintenance and overall operating costs.

Lumen Output Over Time
HID vs. gHID

CONCEPTS
• Mesopic Vision: a balance between photopic and scotopic vision

NOTES
[1] The graph above shows a compilation of data from similar applications at auto dealer installations and others where the pole heights and fixtures were similar. The data was collected over a 2-1/2-year period by the Genesys technical team.

Assumption for graph:
1. Measurements are taken from several different locations and applications at different time intervals.
2. The curves above represent a compilation and average of the various data points.
3. Any premature lamp failures for the 1000W are not included in this data.

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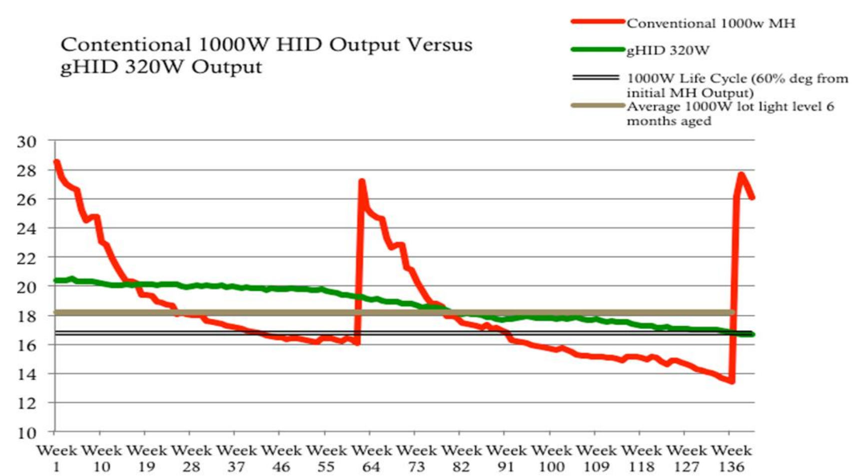
1000W HID lumen output curve versus gHID 320W

The degradation curve of conventionally driven HID lamps (electromagnetically ballasted) is one of the end users' primary pain points. Lamps are considered "non-performing" once they are below 60% of their initial output. This level is typically used as minimum acceptable light levels when designing large area lighting infrastructure. The frequency that these lamps are replaced is a function of the maintenance schedule, desired light levels and standard equipment failures (ballast and lamp) for any given customer or application. The average light output measurements of the conventionally driven 1000W HID lot (50 to 100 lamps) is represented by the violet colored curve. This graph helps illustrate the inherent waste that must be designed into high wattage area lighting projects initially in order to achieve an acceptable maintenance routine.

While the 320W gHID system does not produce the initial lumens of a new 1000W system driven with a conventional ballast, you can see by the data that the gHID system begins to outperform the conventional system in approximately the fourth month both in overall system performance and on any of the individual measurements. This is due to 1) the enhanced initial lumen output and light quality gHID yields with standard lamps, and 2) the significantly flatter degradation curve of a standard HID lamp when driven with the high frequency gHID control gear. The gHID system shows less than a 20% degradation over the 2x extended lamp life.



Note [1]

The gHID system enhances photopic output as well as the scotopic effect (color shift to cool white). The human eye works on varying degrees of mesopic vision. The higher the ratio (S/P) of scotopic to photopic light increases the perceived light seen by the eye in a darker ambient background. Genesys' control gear measures typically in the range of 1.9 to 2.1. For the conventional HID systems an S/P range of 0.7 - 1.6 are most common. This additionally compresses the gap between the initial 1000w outputs versus the gHID 320W.

Due to the flat degradation curve, the uniformity of the lighting system on the site is significantly better. This emphasizes the end user's perception of the quality of the light. Our claim isn't always that we will produce more light, even though in many cases we do see higher photopic readings. gHID produce a higher quality light (cooler and more uniform) than conventional driven HID systems.