Venture's Technical Information:
Ballasts intro and history

INTRODUCTION

While we focus on metal halide, there are practical uses for other HID technologies. We apply the same level of passion for quality and performance to these ballasts as we do to our metal halide offerings. To assure compatibility, refer to our specification sheets to determine which ballast works with which lamp.

The information below introduces ballast function, terminology and proper usage.

Why do we need ballasts?

For many users, ballasts are a mystery. Electrical distribution systems deliver fixed AC voltage (50 or 60 Hz) and expect connected electrical loads to limit the current drawn from the source. Low pressure and high pressure arc discharge lamps exhibit "negative impedance." Without a ballast, the arc will extinguish or draw increasing current until some circuit element burns up. Ballasts provide system stability by limiting the current that can be drawn. Ballasts use inductive and capacitive components because they impede alternating current with little power consumption. Resistive components generate high loss and are usually avoided. This is true of conventional electromagnetic ballasts as well as electronic ballasts.

HID ballasts perform the following functions:

• Provide voltage to breakdown the gas between the electrodes of arc lamps and initiate starting.

• Provide voltage and current to heat the electrodes to allow a low voltage, high current arc mode to develop (referred to as glow-to-arc transition, GAT).

• Provide enough current to heat and evaporate the light emitting components after an arc has been established. Provide enough sustaining voltage (see Vss) to maintain the arc during warm-up and operation.

• Set lamp current once all the evaporable materials have reached thermal equilibrium.

Breakdown vs. Glow-to-Arc Transition (GAT)

Traditional metal halide lamps (also called "probe start"), and high-pressure mercury vapor (HPMV) lamps utilize an auxiliary electrode to facilitate starting. These lamps are filled with a relatively low pressure of argon gas. Breakdown occurs when several hundreds of volts are applied. The lower the fill pressure, the lower the breakdown voltage and less electrode heating occurs in the subsequent glow mode. Without enough electrode heat the arc mode will not develop. There is a trade off of breakdown voltage and GAT with fill pressure for these lamps. For most mercury vapor lamps sinusoidal output voltages around 220 Vrms suffice. For most metal halide lamps, highly peaked (distorted) output voltages around 300 Vrms suffice. Failing to attain a GAT will destroy lamp electrodes in less than 100 hours.

Uni-Form® pulse start metal halide and high pressure sodium (HPS) lamps dispense with the auxiliary electrode, but have breakdown voltage requirements in the range of several thousand volts. An "ignitor" adds a narrow (μsec wide) pulse near the peak of the output voltage waveform. Some lamps require more than one pulse per half cycle. The minimum output voltage requirement (min. OCV) assures that a GAT will occur. At room temperature, mercury interacts with argon to reduce breakdown voltage. In cold weather or refrigerated spaces, the breakdown voltage requirement goes up. Standard metal halide and mercury vapor ballasts have to supply sufficient output voltage for low temperature starting. This effect is not present in pulse start metal halide and HPS lamps.

The pulse voltage requirement for pulse start lamps assures low temperature starting.

Warm Up

Unlike low pressure lamps, HID lamps have a low initial arc voltage following GAT and warm up over several minutes to final operating voltage. In HPMV lamps this involves the evaporation of a fixed amount of mercury. In traditional metal halide and Uni-Form pulse start lamps, a fixed amount of mercury evaporates and the metal halide salts partially evaporate. For most HPS lamps, this involves the partial evaporation of mercury and sodium as the lamp reaches thermal equilibrium. Traditional and pulse start metal halide lamps have sustaining voltage requirements after GAT to assure the lamp will continue to operate. HPS lamps have a lamp power vs. lamp voltage space (see trapezoid) that has been defined to assure stable warm-up and operation.

Operation

The ballast determines the lamp current in normal operation. by providing the impedance. The combination of lamp current and voltage determines the power consumed by the lamp. The lamp power, in turn, determines light output and color. For example if a 320 watt lamp is accidentally operated on a 350 watt ballast, the lamp will run over wattage at 350 watts because the nominal lamp voltage is the same for both lamps and the ballast delivers the current required for a 350 watt lamp. Color will be warmer, light output will be higher and lamp life will be shorter.

In stable operation, lamp power varies with supply voltage and lamp voltage. Electronic ballasts can be designed to minimize both sources of power variation. On lag and HX ballasts, lamp power varies about 2% for each 1% of line variation. On CWA and CWI ballasts, lamp power varies about 1% for 1% of line variation. These ballasts amplify lamp voltage variations into power variations while lag and HX ballasts minimize the same.

BALLAST HISTORY

Most of the world uses “lag” type ballasts for the operation of high intensity discharge (HID) lamps. Another common name for the simplest type of lag ballast is “reactor”. These ballasts are constructed from steel laminations and wire coils. The term “lag” derives from the inductive nature of the ballast; the input current lags the input voltage by up to 90 electrical degrees. Several input taps may be provided to accommodate small local variations in nominal voltage. Reactor ballasts provide outstanding lamp performance, with excellent efficiency, at the lowest possible cost.

Lag ballasts that can accommodate a wide range of input voltages are made using an autotransformer stage in front of an inductive element. These use two coils and are referred to as HX or high leakage reactance autotransformers. The losses and material content are higher resulting in higher operating and initial costs. The lamp performance benefits are retained.

The CWA, or constant wattage autotransformer ballast, became popular in North America for mercury vapor lamps after World War II. The primary application was roadway lighting. The circuit delivers relatively constant lamp current, which, in turn, translates to relatively constant lamp power as long as lamp voltage does not vary with power input during life. This is a good assumption for mercury vapor lamps. It allowed utilities to start a roadway circuit with as much as +13% input voltage at the beginning of a string of lights and allow for sag to —13% at the end of the string. The resulting lamp power variation was an acceptable ±15%. A small “peaking” capacitor across the lamp terminals provided enough voltage to start lamps outdoors with modest OCV. The strategy had little to do with temporal variations in line voltage, but rather addressed the economics of lighting circuits along long stretches of road.

When HPS lamps were introduced, they were incompatible with CWA ballasts because they required a high starting voltage. The constant current characteristic led to unstable operation. Lag and HX ballasts with electronic ignitors became the preferred circuit types. Later, CWA circuits were developed for HPS lamps that depart from a constant current characteristic and incorporate ignitors.

Metal halide lamps were introduced in the 1960’s. They required a higher peak starting voltage than mercury vapor lamps, but were incompatible with “peaking capacitors.” The lamps would start and promptly “drop out.” By adding saturable elements to the magnetic circuit of the ballast, the OCV could be “peaked” to start the lamps. Probe start metal halide lamps and “peaked lead” ballasts launched metal halide lighting in North America. Internationally, the same lamps operated on lag ballasts by adding simple low cost ignitors. Multiple input voltage taps for CWA ballasts were readily accommodated. More ballasts could be operated on a circuit than lag or HX ballasts of the same wattage. However, the current wave shape left little margin for input voltage fluctuations during starting, had poor energy efficiency and provided poor regulation of lamp power with respect to lamp voltage. Evidence suggests that maintained lumens of most metal halide lamps operated on CWA ballasts are worse than those operated on lag circuits.

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