Title: Prevention of early switching life failure of Metal Halide and other HID lamp-Invention of Dragon Kink effect

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Abstract:

Frequent power supply interruption is very common in most parts of Asia and Africa. Declared lamp life is based on one switching in 24 hours as per IEC 61167 for M.H lamp and IEC 60662 for SON lamp. Minimum pulse amplitude and energy required for ignitor pulses has been specified in IEC 60926/927 specification for starting a lamp. As on date there is no higher limit of ignitor pulse energy in IEC 60926/927 specification .Neither the lamp manufacturers specifies maximum pulse energy which MH/SON lamp could be subjected so that switching life does not get affected. With energy conservation in mind lamps are also switched on/off repeatedly to save power. Repeated switching on/off with ignition pulses of energy content reaching lamp greater than 0.75 mJ (may vary depend on discharge tube) reduces switching life of lamp. Maximum energy of ignitor pulse which lamp can be subjected for switching on/off without sacrificing switching life is termed as critical energy(Le) .

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Text:

1 . .<u>Metal Halide Lamp Discharge</u>:

Light is generated in Metal Halide (M.H) lamp by high-pressure mercury discharge to which other light emitting additives are added. The gap in visible spectrum of mercury radiation is filled up by radiation from these additives. During discharge the additives vaporizes as their halides. Three types of additives are in common use for providing white light..

a) Combination of Sodium (yellow), Thallium (green), and Indium (blue) – also known as line radiator.

b) Scandium- a rare earth metal-it has many emission lines. Also known as multi line radiators.

c) Tin Halides and rare Earth Halides –which emit lights due to vibration and rotational effect. They emit light as wide bands.

When halides vapors as in a) and b) enters the discharge area of a burning discharge tube , molecules of halide vapor dissociates into ions and start radiating light.

Wide spectrum emission of light by excitation of molecular radiators as mentioned in c) take place when tin halide/rare earth halide molecules come in contact with outer region of the arc, where molecules of the halides gets adequately excited due to the temperature of the arc and emits wide spectrum of visible light. The temperature of the arc at the outer region is not sufficient to ionize the molecules.
Normally during burning the tip temperature of tungsten electrode are 2800 K to 3300 K. Which is below the melting temperature of tungsten. During burning operation- vaporized mercury create pressure in the discharge tube from few bars to 50 bars for very short lamps.
During burning operation temperature of center of arc could be around 6000K and lower and upper part of the arcs could be around 1100K and 1250 K respectively.
So during life the discharge tube is under stress due to high pressure, corrosive halide vapors and very high temperature causing wear and tear of the Discharge tube, blackening its envelop and erosion of electrode.

Lamp Starting:
In cold state mercury vapor and halides are in non-ionized state. Impedance between two electrodes are very high. To overcome this impedance we need to ionize the mercury vapor. A high amplitude pulse in the order of 3.5 KV or more with sufficient energy that can create an initial arc. Minimum limit for amplitude has been specified in IEC60926/927 specification. Ignitor pulses continue to support ionization till current through the lamp becomes 90 percent of the rated value or voltage across the lamp 110 percent of rated value. Declared life of lamp is based on one switching per 24 hours.
In many parts of Asia and Africa frequent power supply interruption is very common. For example in eastern India average 5 to 6 power supply interruption observed per 12 hours burning of the lamp per day. So the lamps are also switched on/off 5 to 6 times during their 12 hours burning(Average) per day. This causes repeated dissolution /erosion of thorium coated tungsten electrode. This phenomenon is also observed in indoor sports stadium where lamps are repeatedly switched on/off according to sports fixture. to save energy.
So we find there are two parameters, which determine the life of Metal Halide and other HID lamp

i) Ageing- No of burning hours.
ii) Switching- No of switching on/off cycle.

Till date, data supplied by lamp manufacturer for successful ignition is

a) Minimum amplitude of ignitior pulses
b) Pulse duration.

Maximum energy content of ignitor pulse is unrestricted, it has been also not specified in IEC60926/927 specification.
Field report from luminaries manufacturers say

a) Lamp failures in 18 meter tower(lighting Mast) are less than 6 meter tower ,where as components such as pulse ignitor (internationally certified) ,ballast and lamps and luminaries are same(control gear for the luminaries are at the bottom of the tower)
b) 30 percent of Metal Halide Lamps in street light fails in 6 months or early when pulse ignitors used ,compare to superimposed ignitor(ignitor which can ignite lamp at short distance). Ignitors inbuilt into the luminaire

Field report from manufacturer of (who manufacture both) luminaries and control gear say that Metal Halide lamp with long distance ignitor used inbuilt into the luminaries has more failure than ignitor which can ignite lamp at short distance. SON lamp also has problem but much lesser than Metal Halide lamp.
All of the observation are related to places where average 5 to 6 power supply interruptions are observed per 12 hours burning of the lamp per day.

To understand the failure mechanism, experimentation as mentioned below were carried out
Test setup:

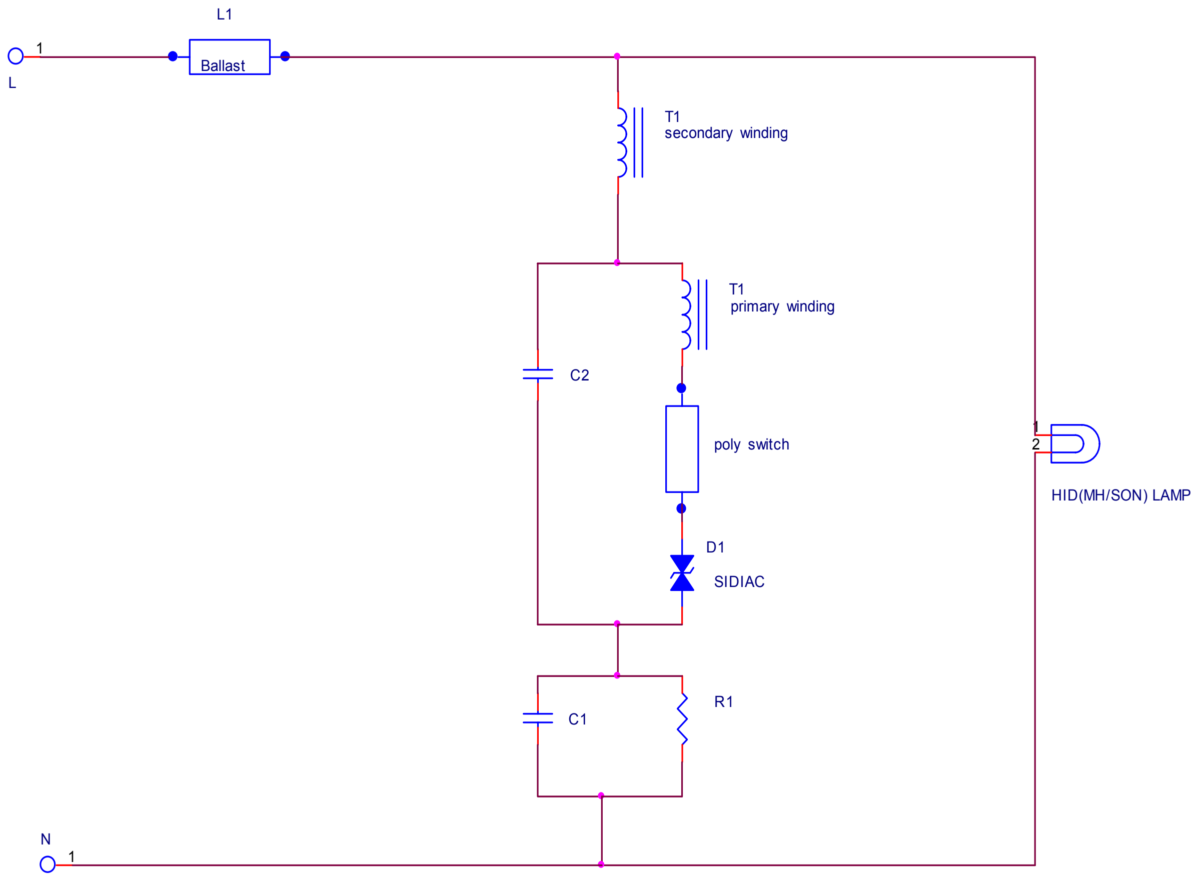

FIGURE ‘A’

Ignitor circuit diagram provided in figure A operates as described below. Voltage multiplier T1 has two sections, Primary and secondary. Low amplitude pulses (180V to 200V) discharged in the primary is converted to high amplitude pulses (4.2 KV to 5 KV) in the secondary of the multiplier, which is applied across the discharge tube for ignition to start.

Pulse width of the output pulse from secondary of the multiplier depends on value of the capacitor C2 and the energy content is (½ CV^2).By varying capacitor value we can generate different energy content of output pulse of ignitor

High Voltage Diac (Sidiac) used in Figure A breaks down when voltage across capacitor C2 reaches its selected breakdown voltage. Current flows through primary of voltage multiplier thus producing high voltage across the lamp through secondary of the voltage multiplier. Through selection of breakdown voltage of Sidiac or by changing ratio of multiplier we can vary output pulse voltage of ignitor.
When metal halide and sodium vapour lamp is fully ignited, lamp voltage would be around 100 V and voltage across High Voltage Diac (Sidiac) used in Figure A will be less than 180 V ,this will make ignitor to stop generating pulses.
Capacitor C1 and R1 decides charging time for capacitor C2 and limit current through Ignitor during closing of Sidiac in Fig. A. Poly switch opens when current flows through it for a longer duration thus sensing a defective lamp /no lamp.

METHOD:

By selecting capacitance value C2 with SIDIAC 180 Volt prepared ignitors of

a) 47 nF energy content 0.76 mJ
b) 68 nF energy content 1.10 mJ
c) 180 nF energy content 2.91 mJ
d) 330 nF energy content 5.346 mJ

With constant amplitude 4.2 KV

Metal Halide lamps were subjected to switching on/off test for 30 days with 3 hrs on and 1 hr off time.
It revealed wonderful observation.

1. 10 new lamps that are subjected 4.2 KV/0.76 mJ pulse had no failure due to switching on/off . Ignition time for 90 percent lamp current from cold state 3.2 minutes
2. 10 new lamps that are subjected 4.2 KV/1.1 mJ pulse had apparent 1(one) failure due to switching on/off ,however the lamp could be ignited with 4.2 KV/2.91 mJ ignitor pulse. Ignition time for 90 percent lamp current from cold state is 2.9 minutes
3. 10 new lamps that are subjected 4.2 KV/2.91 mJ pulse had apparent 3(three) failure due to switching on/off ,however one of the lamp could be ignited with 4.2 KV/3.56 mJ ignitor pulse and one (1) more apparent failed lamp could be ignited

with 4.2 KV/5.346 mJ pulse . Ignition time for 90 percent lamp current from cold state 1.9 minutes.

4. 10 new lamps that are subjected 4.2 KV/5.346 mJ pulse failed to survive 100 switching cycles. All 10 lamps failed between 36 to 56 cycles. Ignition time for 90 percent lamp current from cold state was really fast only maximum 25 seconds.

From the above it can be concluded that,

This maximum energy which lamp can be successfully subjected is termed as critical energy (Le) Typically 0.75 mJ (may vary depending on discharge tube parameter).High amplitude high energy ignition pulses greater than critical energy(Le) causes dissolution / erosion of electrode of Metal Halide(M.H) and Sodium vapor (SON) lamp, this results in increase in minimum ignition energy required to ignite a Metal Halide(M.H) /Sodium vapour (SON) lamp with increase in number of switching ON/OFF operation . Higher the energy content of high amplitude pulses of ignitor, rapid is the increase in minimum ignition energy at which HID lamp ignites for subsequent switching on. This phenomena of increase in minimum ignition energy required to start Metal Halide(M.H) and Sodium vapor (SON) lamp with increase in no of switching on/off due to impact of high energy pulses of Ignitor is named as **"Dragon Kink" effect. This phenomena is more prominent in Metal Halide lamp**. This phenomenon of increase of ignition energy with no of switching on/off determines switching life of the lamp. However this increase of ignition energy which can start a lamp with increase in no of switching on/off cycles could be almost arrested if lamps are ignited with ignitor pulses reaching lamp has energy content less than critical energy(Le)

So in the summary we can say that we need to develop an ignitor system that takes care of 'Dragon Kink'effect

a) Energy content of igniter pulses across the lamp are adequate for stating but below critical limit (Le) as need to be declared by lamp manufacturer/IEC specification for ensuring availability of total useful life by preventing early switching life failure.
b) Useful minimum and maximum distance marked on the ignitor to take into account of Dragon Kink effect so that full switching life of Metal Halide Lamp/other HID lamp is available

Optiional features

a. Provide ignition pulse directly across the lamp.
b. Does not use the ballast as a transformer
c. Does not draw current more than 100mA during ignition and less than 5 mA current when lamp is fully ignited.
d. Senses a defective lamp/ non availability of a good lamp and switches off ignition pulses periodically,
e. Igniter ceases to produce pulse when lamp is ignited.

References:

1. IEC Specification: IEC60927/60926 FOR IGNITORS : IEC IEC 61167 for M.H lamp and IEC 60662 for SON lamp
2. Philips laboratory research data
3. GE lamp data sheet
4. Philips lamp data sheet

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1.Crompton Greaves Lighting Division for the project.
2.Sigma search light ,Kolkata
3. Philips Lighting division