CHAPTER I

EVALUATING AND APPLYING NEON GLOW LAMPS [1]

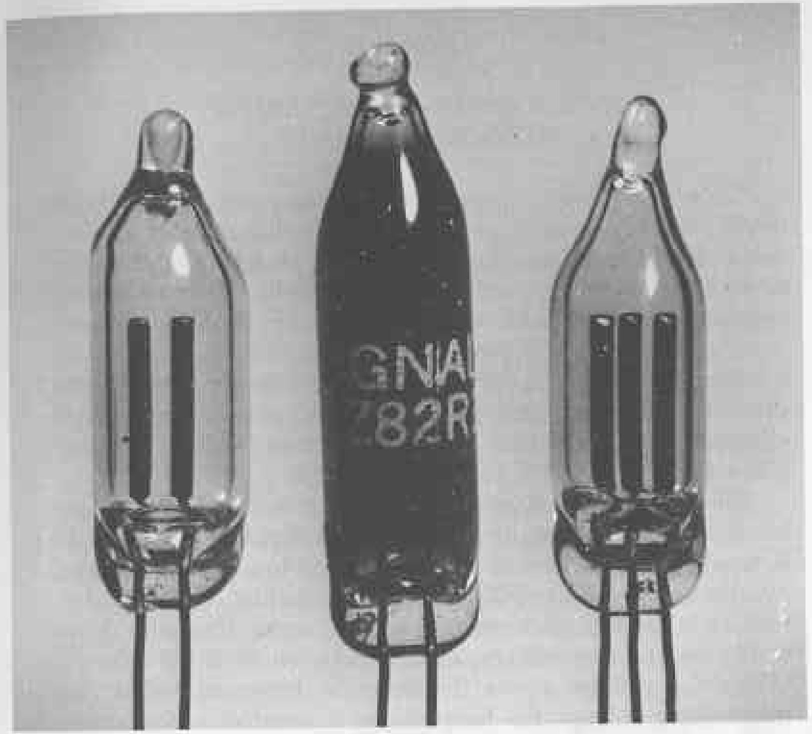
Neon glow lamps, or perhaps more correctly cold cathode diodes, are becoming a product of increasing interest to electronic design engineers. Because of their versatility and ability to do a variety of jobs well and economically, they are finding increasing applications in electronic circuitry. Because it is now possible to design and produce neon lamps to the same close tolerances and specifications as other electronic components, they are now used with complete confidence as circuit logic elements, photochoppers, voltage regulators, timers, X-Y matrices, memory circuits, and in many other circuits.

The neon glow lamp consists of an anode and cathode housed in a glass container filled with rare gases. (Figure 1-1) It breaks down or ionizes when subjected to a certain voltage, usually between 66 and 200 volts dc depending on design. Immediately after breakdown, the voltage across the lamp drops to the maintaining voltage, usually between 48 to 80 volts dc. When the voltage across the lamp is decreased below this maintaining voltage, the lamp ceases to conduct and abruptly extinguishes.

Neon lamps operate with currents ranging from .1 milliamp to 10 milliamps. Lifetimes can be greater than 50,000 hours of continuous operation. Lamps meeting specific values within these ranges can be designed.

The amount of time it takes for the lamp to start conducting after application of the breakdown voltage is known as the ionization time. If the applied voltage is just equal to the lamp's specified breakdown voltage, this time may be hundreds of milliseconds. However, if the applied voltage is 30% or greater than the breakdown voltage, the ionization time may be as low as 10 microseconds. Recently developments in lamp design, however, have produced lamps which ionize as fast as 4 microseconds.

1. Bauman, Edward, Signalite Inc., "The Complementary Use of Neons and Transistors," *Signalite Application News*, Vol. 2, No. 5.

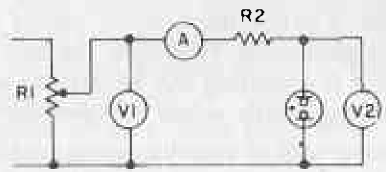


1-1 Types of neon glow lamps

Neon lamps may also be designed with three electrodes instead of two for use in certain switching applications. Characteristically, these lamps will have a relatively high breakdown voltage rating between the anode and the cathode. Applying a voltage to the third electrode, the trigger, however, will ionize the gas in the tube which, in turn, permits current to flow between the anode and the cathode.

The circuit for measuring standard two-element glow lamp parameters is shown in Figure 1-2. With the lamp in the position shown, the potentiometer is turned up until the lamp ignites. At this point breakdown voltage is read on voltmeter, V_1. Then the pot is adjusted until the ammeter reads the design current of the lamp. At this point voltmeter, V_2, reads the maintaining voltage. Turning the pot down until the lamp

stops conducting will indicate the extinguishing voltage on V_1. Ionization time is usually measured on a high speed oscilloscope.



1-2 Circuit for measuring glow lamp parameters

All neon glow lamps require ballasting in the form of a resistor in series with the lamp. The value of the resistor depends on the applied voltage, current, and desired lamp characteristics.

There are also external conditions which affect the operation of neon glow lamps. For example, the existence of an electrostatic field in the vicinity of the glow lamp will noticeably affect its performance. Such a field may decrease the rated breakdown voltage, and cause the lamp to ignite at levels significantly below normal. Electrostatic fields have no effect on maintaining voltage characteristics. High intensity radio frequency can cause the neon lamp to ignite with no applied voltage. These characteristics in themselves may suggest other possible applications.

Neon lamps exhibit a negative temperature characteristic, normally about 40 to 50 millivolts per degree Centigrade. In a voltage regulator this temperature coefficient may be as low as 2.0 millivolts per degree C. This temperature coefficient is small compared to zener diodes of the equivalent voltage. The normal operating temperature specifications for electronic circuitry of $-60°F$ to $+165°F$ are perfectly acceptable to neons.

Another factor that may affect the performance of glow lamps is operating in the absence or presence of light. Lamps operating in total darkness tend to have a higher breakdown voltage than in the light. This light effect, however, can be minimized or eliminated by the addition of a small amount of radioactive material to the lamp during manufacture.

Light output of neon lamps in circuit applications is usually not a matter of prime importance, except when they are being used with photocells. However, the fact that the lamp does glow when it is operating can be used as an indication of circuit operation, especially when inexperienced or untrained personnel are being used to monitor equipment operation. Also, since the glow in a direct current application is confined to the cathode, this characteristic can be used to determine polarity.

Light emitted by standard neon lamps generally averages about .06 lumens per milliamp. The high brightness lamps average about .15 lumens per milliamp. Meaningful measurement in this area is limited because conventional N.B.S. standards are about 1,000 times brighter than neon glow lamps. The light itself is confined mainly to the yellow and red regions of the spectrum between 5200 and 7500 Angstrom. A band in the infrared region between 8200 and 8800 Angstroms is also emitted.

The rated life for neon glow lamps is the length of operating time, expressed in hours, which produces certain specified changes in its characteristics when run at its design current. In lamps used as circuit components, these characteristics are usually the breakdown and maintaining voltage. Because this change is gradual, the end of life occurs when the lamp no longer meets specifications, rather than as a catastrophic failure. Life testing of neon lamps must be conducted at design current and cannot be accelerated. Running a lamp at currents above its design current causes heating of the cathode emissive material. This, in turn, will increase the sputtering of the emissive material, changing the lamp's aging characteristics at a rate that is not reproducible or easily related to its life at normal usage. Consequently, any attempt to accelerate aging at higher currents will not be applicable to actual service.

In most circuit applications, neon glow lamps are not "on" all of the time. In these applications only the time during which the lamp has current passing through it determines the

useful life. If this period is a short duration, as in pulsing applications, the rated life will have to reflect the fact that the lamp's useful life is not being consumed while it is inoperative. Actual life would be equal to the lamp's rated life divided by the operating duty cycle. In many applications, the actual rated life, i.e. calculated operation time of the lamp, will exceed by many times the estimated lifetime of the equipment or circuit in which the lamp is installed.

The life expectancy of a neon glow lamp, of course, depends on the operating conditions of the lamp, with life increasing as operating currents are decreased. If the lamp is installed in a circuit where it will be subjected to pulsing, the peak current, pulse wave shape and pulse duration all will have their effect on lamp lifetimes. Lifetimes may range from 1,000 to 50,000 hours of continuous operation. Operation on direct current rather than alternating current will shorten figures, perhaps up to 50% in some installations, because of the fact that only one electrode is being used instead of both. As a rule of thumb, average circuit component neon lamps will have rated lifetimes in the area of 7,500 hours of continuous operation.

Because of the wide variation of lamp characteristics available, and because of the wide variation in conditions of application, it is extremely important to consult with the engineering group of the glow lamp manufacturer in the determination of the proper lamp to use in any given situation. Where a standard lamp may be completely unsatisfactory for circuit component use, with only minor design changes, it may be made to perform well. The cost of such changes, even the cost of designing a completely new lamp, is almost always relatively insignificant when viewed in terms of the job to be done, the cost of other components in the system, or the cost of alternative ways to accomplish the task.

Ten Key Points in Evaluating and Applying Neon Glow Lamps

1. Consider the neon glow lamp in the context of a circuit component, not as an extension of the classical indicator lamp. It can meet critical specifications.

2. Know the important parameters and characteristics of neon glow lamps for circuit application, and specify lamps within them.

3. Relate your measuring techniques of these parameters to those used by the manufacturer. This can save untold time and expense in inspection.

4. Use the neon glow lamp for the purpose for which it has been designed or recommended. Misapplication of lamps can be costly in terms of discarded units and rework of equipment.

5. Remember that the operation of glow lamps is affected by such external conditions as the presence of electrostatic fields and RF interference.

6. Evaluate the possible effects of other external conditions such as ambient light and temperature.

7. Determine the importance of light output of neons in the application, and the advantages it may offer.

8. Do not attempt to evaluate performance of neons based on accelerated testing programs. Neon glow lamps designed as indicators can not be aged into the reliability required by electronic circuits.

9. Neon glow lamps are long life components. Estimate their lifetimes based on the operation times of the lamps in the circuits. They do not age when not operating.

10. Most important of all, consult the Applications Engineering Group of the neon glow lamp manufacturer for the proper design or selection of circuit component glow lamps.