

Frequently Asked Questions - Neon Transformer

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3.001 How do transformers work?

Transformers are devices that transform voltage up or down by magnetic means. Alternating current (AC) flowing in a primary coil establishes an alternating magnetic flux in a "core" that easily conducts this flux. If another coil (called a "secondary" coil) is positioned on the core near the primary, this flux will link this second coil along with the primary coil. This linking of the secondary coil induces a voltage across the secondary terminals. The magnitude of the voltage at the secondary terminals is related directly to the ratio of the secondary coil turns to the primary coil turns. More turns on the secondary coil than the primary results in a step up in voltage while fewer results in a step down in voltage.

3.002 How are Neon Transformers different from the more common "power" transformers?

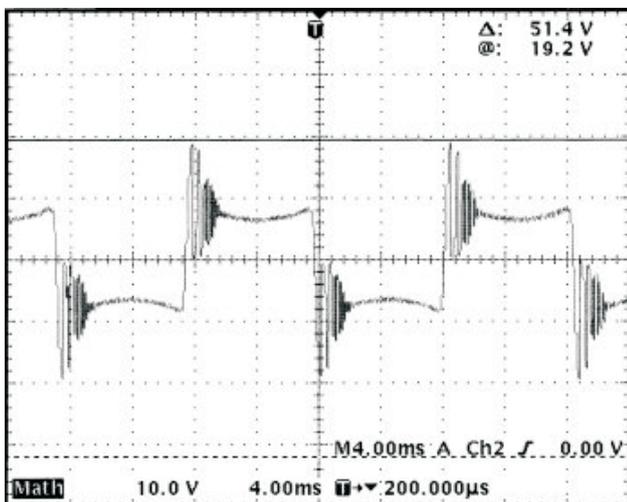
Power transformers have good voltage regulation over varying load conditions. This means the transformer's output (or "secondary") voltage varies only a small amount from minimum to full rated output current. All neon transformers have deliberately poor output voltage regulation made possible by the use magnetic shunts in the transformer. This poor regulation is necessary to limit current in neon tubing. With a large change in output load voltage, the neon transformer maintains output load current within a relatively narrow range.

A neon transformer is rated for its secondary open circuit voltage and secondary short circuit current. Open circuit voltage (OCV) appears at the transformer's output terminals only when no neon tubing is connected to those terminals. Likewise, short circuit current is only drawn from the output terminals if a short is placed across those terminals (in which case the output voltage equals zero). However, when a neon tubing load is connected across these same terminals, the transformer's output voltage will fall somewhere between zero and the rated OCV. In fact, if the transformer is loaded properly, that voltage will be about half the rated OCV.

One might ask, then, "Why do you need that high OCV at all if the loaded output voltage is only half the OCV?" The simple answer is that a higher voltage is required to "ionize" or "break down" the neon and/or argon gas in the tubing than to maintain current through the gas after it breaks down. After the gas breaks down it becomes conductive and the voltage across the tube drops dramatically. (The electrical arc seen in the tubing after breakdown of the gas is the evidence of an electrical current flowing through the tube).

If neon transformer's output voltage were tightly regulated, it would tend to resist this drop in tube voltage by forcing more current through the tube. The problem is, neon tubes respond to higher currents by presenting a lower voltage to the transformer, so that the tube would rapidly burn out. So, a neon transformer is built to allow a drop in tube voltage without forcing excessive current through the tube. After reading earlier paragraph, one could deduce correctly that the neon transformer (barring other outside influences) will never allow more than its rated short circuit current to flow in a neon tube no matter how short the tube.

It should be noted that the transformer has very little influence on its "loaded" output voltage – the tubing actually forces the transformer to a particular voltage, so we should more correctly speak of the loaded transformer output voltage as the "tubing voltage." Tubing voltage is only slightly affected by transformer output current capability, but is largely dependent on the tubing length, tubing diameter, gas type, gas pressure, and in the case of neon/argon filled tubing, the operating temperature. Increases in tubing length, gas pressure, and decreases in tubing diameter cause the tubing voltage to increase. In neon/argon tubes, a decrease in operating temperature increases tubing voltage.



Typical Tube Voltage Waveform
(10000 volts/vertical division)

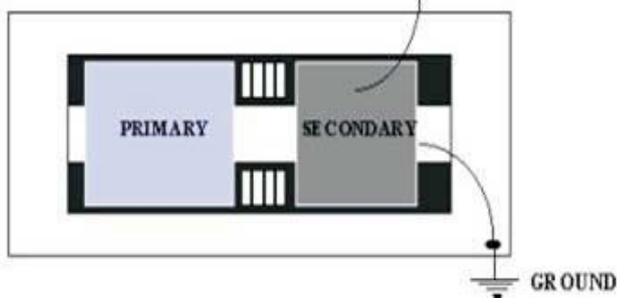
3.003 What is the purpose of the magnetic shunts?

The shunt assembly will bypass some magnetic flux away from the secondary. This allows a lower voltage across the load while limiting the current required. See FAQ "How are Neon Transformers different from the more common "power" transformers?"

3.004 What are the differences in the core and coil designs of one-end-, unbalanced-mid-point-, and balanced-mid-point-referenced transformers?

One-End Referenced Design (formerly one-end grounded)

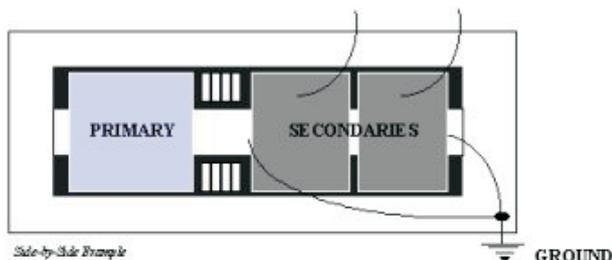
A lower voltage transformer will often utilize a one- end referenced core and coil assembly. This design usually has one primary coil and one secondary coil with one end of the secondary coil connected to the transformer core and enclosure (in SCGFP transformers, this wire may pass through an SCGFP circuit before being connected to the core and transformer enclosure) and the other end being the high voltage lead.



One End Referenced Core/Coil

Unbalanced Mid-Point Referenced Design (formerly unbalanced midpoint grounded)

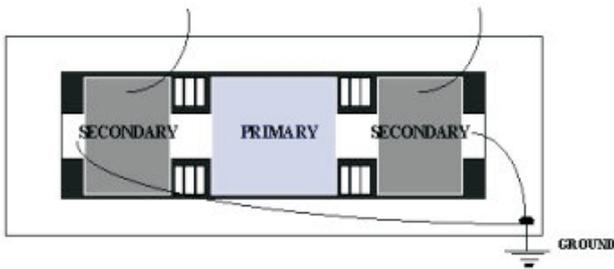
Mid-level voltage transformers often utilize an unbalanced mid-point referenced core and coil design. This design usually has one primary coil and two secondary coils — both of which are mounted together on one end of the core with the primary on the other. One end of each secondary is attached to the core and subsequently to the transformer enclosure (in SCGFP transformers, this wire may pass through an SCGFP circuit before being connected to the core and transformer enclosure). The other end of the each secondary coil is attached to its own output lead or terminal. Thus, with the neon not connected, an unloaded 6000 volt transformer of this type will measure 3000 volts from each secondary terminal to the transformer enclosure, but will measure 6000 volts between the two output terminals.



Unbalanced Midpoint Referenced Core/Coil

Balanced Mid-Point Referenced Design (formerly balanced midpoint grounded)

This is most commonly found in mid to higher voltage rated transformers and most 60 mA transformers. This is the only type transformer acceptable in a "mid-point return wired" system. The "balanced" neon transformer usually has one primary coil with two secondary coils, one on each side of the primary. This transformer can in many ways perform like two transformers. Just as the unbalanced midpoint referenced core and coil, one end of each secondary is attached to the core and subsequently to the transformer enclosure (in SCGFP transformers, this wire may pass through an SCGFP circuit before being connected to the core and transformer enclosure) and the other end of the each secondary coil is attached to an output lead or terminal. Thus, with the neon not connected, an unloaded 15000 volt transformer of this type, will measure 7500 volts from each secondary terminal to the transformer enclosure but will measure 15000 volts between the two output terminals.



Balanced Midpoint Referenced Core/Coil

3.005 What is the theory behind mid-point referenced transformers — balanced versus unbalanced?

Only the balanced mid-point referenced transformer can be used in a “midpoint wiring” system since it performs like two independent transformers on its secondary side. The secondary coils of an unbalanced midpoint referenced transformer are magnetically coupled to one another so that the loading on one secondary will affect the loading of the other secondary, making midpoint wiring impossible.

You must consult the manufacturer or the manufacturer’s literature to be certain as to which type of transformer design is being utilized in a particular model selected for a specific application.

3.007 Why do transformers get warm and how warm is “too warm?”

Transformers, like most devices in nature, are not 100% efficient. Some percentage of the power supplied to the primary never reaches the load connected to the secondary. This power is converted to heat and is considered a loss. Core losses and wire resistance both contribute to the losses in a transformer. These losses generate heat, causing a temperature rise in the unit. These losses cannot be eliminated and must be controlled by proper design and correct application to prevent overheating of the transformer. Underwriters Laboratories standards dictate maximum temperature limits for neon transformers.

3.008 What is the best means to dissipate the heat a transformer produces?

A transformer dissipates heat through convection, conduction, and radiation. Proper ventilation will help carry heat away from the transformer by convection. However, conduction is the most efficient means to dissipate the heat generated by a transformer. Mounting the transformer so that one or more sides of the transformer make surface-to-surface contact to the transformer box, raceway, etc. is the best way to remove heat by conduction (DO NOT DOUBLE NUT MOUNT the transformer — this will dramatically reduce conductive heat dissipation -- use a solid plate under the transformer instead). Ultimately, all heat is “radiated” into the air around the transformer box, raceway, sign body, etc. The larger the surface area of a hot surface, the more efficiently heat is radiated from that surface. This is why it is so important to conductively “heat sink” the transformer to the transformer box, raceway, or sign body because these have a much larger surface area than the transformer itself.

3.009 What is power factor?

Power Factor: The measured power (measured in watts) drawn by a loaded neon transformer from the power line divided by its measured input volt-amperes.

Power is often calculated by the multiplication of volts by amps. This may be true with some loads (such as electric water heaters), but not for neon transformers. In neon transformer applications, the volt-amperes must be multiplied by the power factor to compute the input power.

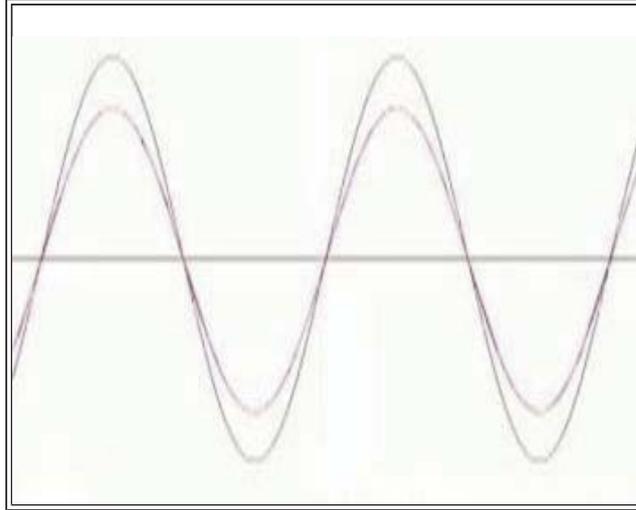
As an example, a 15,000 volt, 30 mA transformer may draw 3.75 amps at 120 volts, or about 450 volt-amperes as shown in most neon transformer catalogs. The actual measured power is about 202 watts. Therefore, the power factor is 202 divided by 450 is 0.43, or 43% as expressed as a percentage.

3.010 What power factor should I expect from a neon transformer?

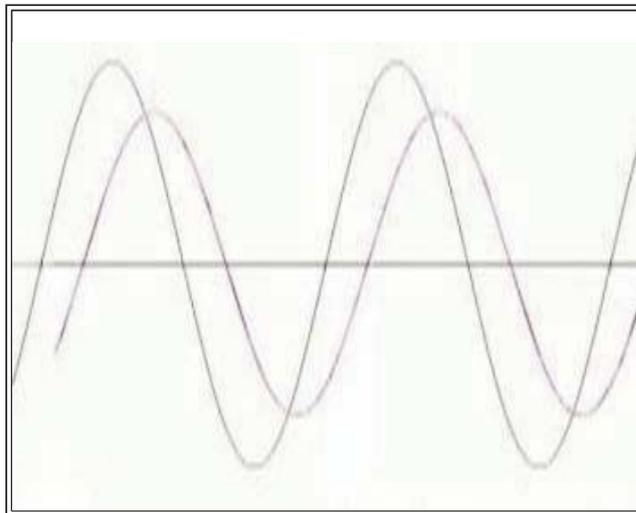
The power factor for most “normal” (as opposed to “high”) power factor transformers is in the 40-50% range. To be considered high power factor, power companies, listing agencies, etc. usually require that the power factor be at least 90%.

3.011 Why is there a difference in power factors?

In alternating current (AC) circuits possessing a line power factor of 1 (or 100%), the voltage and current each start at zero, rise to a crest, fall to zero, go to a negative crest and back up to zero. This completes one "cycle" of a typical "sinewave." This happens 60 times per second in a typical US application. So, we say that such a voltage or current has a characteristic "frequency" of 60 cycles per second (or 60 Hertz) power. Power factor relates to the position of the voltage waveform relative to the current waveform. When they pass through zero together and their crests are together, they are "in phase" and the power factor is 1, or 100%. If they do not pass through zero at the same time, etc. they are out of phase and their power factor is less than 100%.



Two Sinewaves "In Phase"
Voltage (black) "in Phase" with Current (red) => Power Factor = 100%



Two Sinewaves "Out of Phase"
Voltage (black) "leading" the Current (red) => Power Factor ~ 60%

The normal power factor of most neon transformers is largely due to the effect of the magnetic shunts and the secondary coil, which effectively add an inductor into the transformer's output circuit to limit current to the tube load. The power factor can be increased to the required 90% (high power factor) by the use of capacitors placed across the primary coil of the transformer, which brings the input voltage and current waves more into phase.

Note: Use of high power factor transformers does not lower the electrical bills paid by the sign owner as is often mistakenly believed. In some cases, however, power companies charge penalties to large users that do not utilize power factor corrected equipment. Utility companies put out VA (volt-amps) but get paid in Watts.

Example: 15030 P vs. 15030 PC (approximate wattage) _____

P (watts) = V (volts) x I (amps) x Pf (power factor)
15030 P => P = 120 V x 3.75 A x 0.45 = 202 Watts
15030 PC => P = 120 V x 1.8 A x 0.93 = 201 Watts

3.012 Are normal power factor and high power factor transformers interchangeable?

Yes. (SEE NOTE BELOW) The output characteristics of a 15030 P (normal power factor) and a 15030 PC (high power factor) are the same — 15,000 VAC open circuit and 30 mA short circuit -- but a high power factor transformer requires less input amps.

This advantage allows for:

- More transformers on a given circuit
- Reduction in installation and construction costs by allowing smaller size wire or fewer circuits
- Or, allows an increase in sign size utilizing existing wiring

Note: When changing out from normal power factor to high power factor transformers, the required input amps will drop, but when changing from a high power factor to a normal power factor, the input amps will almost double! Be sure that you do not overload the circuit.

Check the circuit to determine the amp load. High power factor transformers use half the input amps of the normal power factor transformer. If the circuit will allow for the additional input amps, then you can use the normal power factor unit.

3.013 How Do I Calculate the Cost of Operating a Neon Transformer?

For Normal Power Factor Transformers	$\$/\text{day} = \frac{I_p \times V_p \times (\text{hrs}/\text{day}) \times (\$/\text{kwh})}{2200}$ <p style="text-align: center;">OR</p> $\$/\text{day} = \frac{VA_p \times (\text{hrs}/\text{day}) \times (\$/\text{kwh})}{2200}$
For High Power Factor Transformers	$\$/\text{day} = \frac{I_p \times V_p \times (\text{hrs}/\text{day}) \times (\$/\text{kwh})}{1050}$ <p style="text-align: center;">OR</p> $\$/\text{day} = \frac{VA_p \times (\text{hrs}/\text{day}) \times (\$/\text{kwh})}{1050}$

Where:

I_p = primary amps

V_p = primary volts

VA_p = primary VA

kwh = kilowatt-hours

hrs/day = operating hours per day

How were these formulas derived?

Calculating the Cost of Operating Neon Transformers

For Normal Power Factor Transformers:

$$\$/\text{day} = \frac{(\text{primary amps}) \times (\text{primary volts}) \times (\text{hrs operated per day}) \times (\$/\text{kwh})}{2200}$$

OR, since primary VA = (primary amps) x (primary volts)

$$\$/\text{day} = \frac{(\text{primary VA}) \times (\text{hrs operated per day}) \times (\$/\text{kwh})}{2200}$$

For High Power Factor Transformers:

$$\$/\text{day} = \frac{(\text{primary amps}) \times (\text{primary voltage}) \times (\text{hrs operated per day}) \times (\$/\text{kwh})}{1050}$$

OR

$$\$/\text{day} = \frac{(\text{primary VA}) \times (\text{hrs operated per day}) \times (\$/\text{kwh})}{1050}$$

Explanation of Formulas

$$\text{Primary watts} = (\text{primary amps}) \times (\text{primary volts}) \times (\text{power factor})$$

$$\text{Primary kilowatts} = \frac{\text{primary watts}}{1000}$$

$$\text{Primary kilowatts} = \frac{(\text{primary amps}) \times (\text{primary volts}) \times (\text{power factor})}{1000}$$

$$\text{Primary kilowatt-hrs} = \frac{(\text{primary amps}) \times (\text{primary volts}) \times (\text{power factor}) \times (\text{hrs operated})}{1000}$$

$$$/day = \frac{(\text{primary amps}) \times (\text{primary volts}) \times (\text{power factor}) \times (\text{hrs operated}) \times (\$/\text{kilowatt-hrs})}{1000}$$

Primary VA (VA_p) equals I_p x V_p.

For normal power factor transformers power factor averages 0.454, so the formula reduces to:

I_p V_p PF hrs/day \$/kwh

$$$/day = \frac{(\text{primary amps}) \times (\text{primary volts}) \times (0.454) \times (\text{hrs operated}) \times (\$/\text{kilowatt-hrs})}{1000} \text{ OR,}$$

$$$/day = \frac{I_p \times V_p \times (\text{hrs/day}) \times (\$/\text{kwh})}{2200} \quad \text{OR,} \quad \$/day = \frac{VA_p \times (\text{hrs/day}) \times (\$/\text{kwh})}{2200}$$

With high power factor transformers power factor averages 0.952, so:

I_p V_p PF hrs/day \$/kwh

$$$/day = \frac{(\text{primary amps}) \times (\text{primary volts}) \times (0.952) \times (\text{hrs operated}) \times (\$/\text{kilowatt-hrs})}{1050} \text{ OR,}$$

$$$/day = \frac{I_p \times V_p \times (\text{hrs/day}) \times (\$/\text{kwh})}{1050} \text{ OR,} \quad \$/day = \frac{VA_p \times (\text{hrs/day}) \times (\$/\text{kwh})}{1050}$$

3.014 What is “overloading” and what affect does it have on a transformer’s life?

Overloading, or the connecting of more tubing than recommended, produces higher secondary voltages resulting in increased stress on the transformer and sign insulation system. This stress can cause secondary coil failure and reduced transformer life and premature failure of high voltage sign components. Overloading can also cause tube flicker creating high voltage and current peaks in the secondary coils, damaging the insulation system in the transformer and sign, and again, significantly reducing transformer life.

3.015 What is “underloading” and what effect does it have on a transformer’s life?

Underloading, or connecting less tubing than recommended, forces the transformer to supply more tube current than normal, resulting in increased wire loss and higher operating temperatures in the transformer. This reduces the life of the transformer.

3.016 What affects can over- or underloading have on tubing life?

Overloading the transformer to the point of hard starting or flicker can reduce the life of tubing electrodes. We are unaware of any significant affect that underloading would have on tubing life; however, we suggest you contact the tubing vendor directly.

3.017 What tests can be performed to see if the transformer is properly loaded?

Loading a magnetic transformer is easy when the basic loading practices are followed. Determine the following:

- Neon or Mercury / Argon tube?
- Tubing diameter?
- Total tube footage (add one extra foot for each pair of electrodes)?
- Current rating (30 or 60 milliamps)?

Use this data with the Luminous Tube Footage Chart as a guide to initially determine the needed transformer size. To confirm this selection, we suggest three tests: The Short Circuit Test, Flicker Voltage Test, and Load Voltage Test.

Load to Short Circuit Current Ratio Test

You will need a 0-100 mA milliammeter, a multimeter, and a variable transformer (Variat) for this test. Neon transformers are designed to be loaded to approximately 80% ($\pm 2-3\%$) of their measured short circuit current for Mercury / Argon, and 85% ($\pm 2-3\%$) for Neon. Using the milliammeter, determine the transformer’s short circuit and load current (see Figures 1 and 2 below). Calculate the load to short circuit current ratio by dividing the measured load current by the short circuit current [i.e., $24\text{mA} \div 30\text{mA} \times 100 = 80\%$.] If the result is too high, the transformer is underloaded; if too low, it’s overloaded.

WARNING: POTENTIALLY HAZARDOUS HIGH VOLTAGES CAN BE PRESENT. HANDLING, TESTING OR SERVICING SHOULD BE ACCOMPLISHED ONLY BY QUALIFIED PERSONNEL.

Figure 1
Short Circuit Current Measurement

1. Turn off and/or disconnect the power supply/variatic.
 2. Using the GTO (high voltage) cable connect the AC milliammeter across the high voltage terminals of the transformer.
 3. Reconnect the power supply/variatic, turn on and adjust to the rated input voltage of the transformer
 4. Read and record the value shown on the milliammeter.

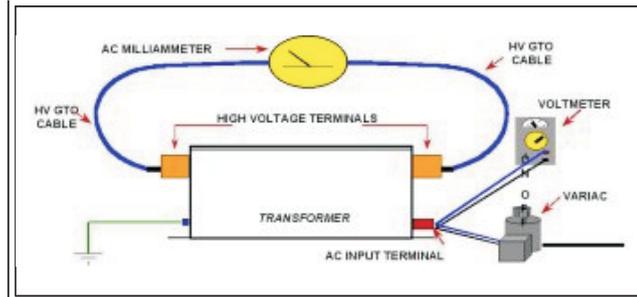
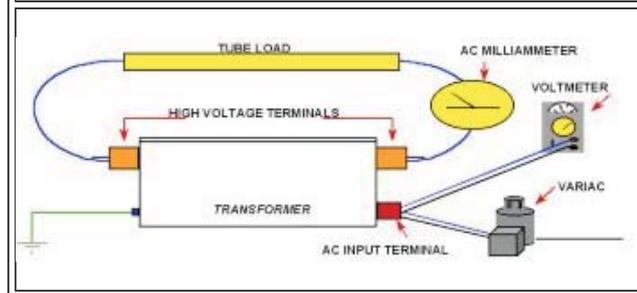


Figure 2
Load Current Measurement

1. Turn off and/or disconnect the power supply/variatic.
2. Using the GTO (high voltage) cables, connect the tube load in series with the milliammeter to the transformer high voltage terminals.
3. Reconnect the power supply/variatic and turn on to the rated input voltage of the transformer.
Caution: do not touch the ammeter.
4. Read and record the value shown on the milliammeter.



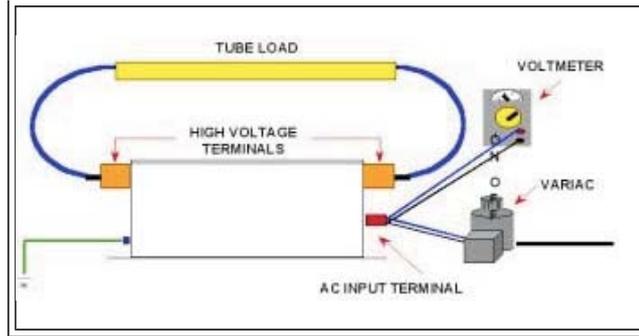
Flicker Voltage Test

The flicker voltage test (see Figure 3) is accomplished by using the variac to slowly reduce the transformer primary voltage from rated until the tube load flickers. If the reduced voltage is greater than 75-78 % of the transformers rated input voltage, evaluate the next highest size transformer

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Figure 3
Flicker Voltage Measurement

1. Connect the variac and voltmeter to the AC input terminal.
2. Turn on the variac and adjust its output to the rated input voltage of the transformer.
3. Decrease the input voltage using the variac until tube flickers.
4. Read and record the voltage when flicker occurs.
5. If voltage is greater than 75-78 % of the transformers rated input voltage, evaluate the next highest voltage transformer.



Load Voltage Test

To best optimize the loading of a particular transformer running a neon load, the load voltage should fall within a certain range. The load voltage may only be measured from one output leg to ground while the transformer is operating normally (loaded). Equipment needed:

True RMS Multi-Meter:

Wavetek 85XT True RMS Digital Multi-Meter

Source: Allied Stock No. 743-0031

PH (800) 433-5700

OR

Wavetek RMS225 True RMS Digital Multi-Meter

Source: Grainger Stock No. 3T267

PH (800) 323-0620 for local store #

OR

[Recommended]

Fluke 83 True RMS Digital Multi-Meter

McMaster-Carr No. 7092K77

PH (404) 346-7000

FX (404) 349-9091

High Voltage Probe:

Fluke 80K-40

Carlton-Bates Co.

(800) 264-1232

[Recommended]

AC/DC High Voltage Probe

McMaster-Carr No. 65725K13

PH (404) 346-7000 FX (404) 349-9091

Connect the prospective tube load to the transformer. Measure the voltage from each high voltage output leg to ground. The voltage should fall within the range for listed for each rating below. If the measured voltage is higher than the range, move to the next higher voltage rated transformer or reduce total tubing length.

Output Rating		Load Voltage Each Leg to Ground (Range)
Volts	mA	
15000	30/60	3000 to 3800
12000	30/60	2400 to 3000

10500	30	2100 to 2600
9000	30/60	1800 to 2250
7500	30/60	1500 to 1875
6000	30/60	1200 to 1500
5000	30/60	000 to 1250
4000	30/60	800 to 1000
3000	30	1200 to 1500 **
3000	60	600 to 750

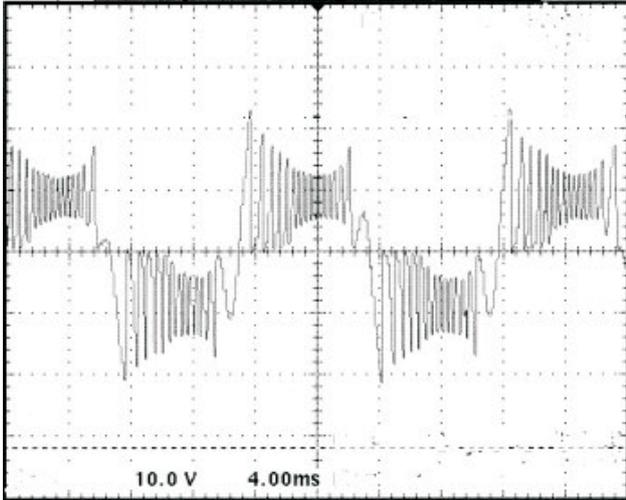
* Voltage measured using the equipment listed above. DO NOT measure voltage leg to leg using the probe and meter listed above. This meter and probe is only intended to measure high voltage from leg to ground - See manufacturers instructions for use of the meter and the probe.

** All 3000V 30mA France transformers are one end grounded.

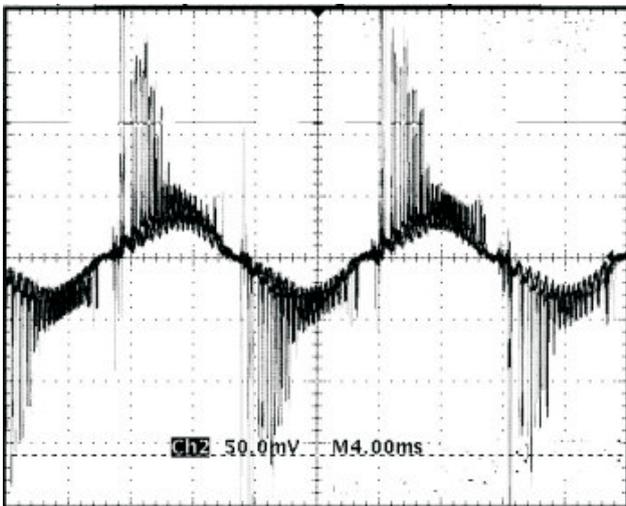
3.018 What is “capacitance effect” in sign systems?

Why is a 20 feet limitation placed on GTO in metallic conduit in a neon sign system?

The 1999 National Electrical Code limits to 20 feet the maximum run of GTO cable in metallic conduit from a neon transformer's high voltage outputs to the first electrodes in a neon sign system. A good reason exists for this limitation. GTO in conduit adds capacitance between the high voltage output of the neon transformer and ground and the longer the conduit, the more the capacitance. This capacitance acts with the output impedance of the neon transformer in such a way as to increase the peak voltage and currents within the transformer's high voltage secondary coils. Increases in peak voltage and currents in the transformer reduce the life of both the transformer and sign system's other high voltage components. As the length of GTO in metallic conduit starts to approach 20 feet, the increased capacitance in the GTO/conduit begins to approach something called "resonance" with the output impedance of the some transformers. This resonance effect makes the peak voltage and currents increase in a dramatic way, with corresponding dramatic reductions in the service life of both the transformer and sign system high voltage components. Lengths of conduit beyond 20 feet simply make the resonance effect even more dramatic. While this effect is more pronounced on some neon transformer ratings than others, this effect will occur at some length of conduit on all transformers.



Tubing Voltage with 20' of GTO15 in 1/2" Metal Flex Conduit on 15000 volt, 30 mA Transformer



Tubing Current with 20' of GTO15 in 1/2" Metal Flex Conduit on 15000 volt, 30 mA Transformer

The rules of thumb are keeping all GTO lengths as short as possible and utilize midpoint or "virtual midpoint" wiring wherever possible.

3.019 Is there a way to measure if the capacitive current will have negative effects on the transformer?

Measure the secondary output voltage under loaded conditions. If the voltage is more than 60% of its open circuit voltage rating, the system will be affected by the capacitive current.

3.020 Why does a sign still flicker when only one lead is connected?

Current is still flowing through tubing even though only one lead is connected. The tubing electrode connected to the transformer forms one plate of a capacitor while the other plate of the capacitor is earth ground. Since the transformer is usually grounded and its output voltage is so high, enough current will sometimes still flow through this capacitance to ground to partially break down the gas in the tube as evidenced by perceptible glow in the tube.

3.021 Are 60 mA transformers better for cold weather applications?

The brightness of Mercury/Argon tubing is dramatically reduced as air temperature decreases – in particularly cold climates, a 60 mA transformer may be preferred.

3.022 What is radio interference and why does it occur?

Radio Interference is any signal, whether radiated as radio waves or conducted on the power lines, which hampers reception in radio, television and other similar equipment.

The first radio transmitters used arc discharges to produce radio frequency noise that could be detected by a distant receiver. Neon signs utilize arcs within a glass tube filled with an appropriate gas.

Although not to the same degree, the arc of a neon tube generates radio noise in a similar fashion as spark gap transmitters of yesteryear. These early transmitters utilized an antenna to radiate the radio waves over distance. In a similar way, the neon tube itself acts as an antenna broadcasting the radio frequency interference (RFI) over some unknown distance. This generated noise can also be conducted back through the transformer and the power lines possibly requiring a filter to inhibit this interference.