

Joslyn Clark Controls, Inc.

## **Current Chopping, A Simple Explanation**

*Calculations to Determine Transient Voltages  
When Using Vacuum Interrupters*

Current chopping is a term that came to our vocabulary with the advent of vacuum switching which was commercially started back in the 1950's. Earlier switching means in air or oil are in terms of dielectric recovery rate relatively slow and as the main contacts would part the arc would go through several zero crossings before it would finally go out and the dielectric strength across the now open gap be strong to prevent a restrike, and thus continuation of current for a further half cycle. With the introduction of vacuum as a dielectric medium that has a completely different characteristic to that of air or oil dielectrics in so much that it has a very rapid dielectric recovery rate.

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Upon opening the main contacts of a vacuum interrupter whether it be a circuit breaker or a contactor, high velocity movements are easily obtained because of the low mass and small movements required to obtain arc isolation up to limited high voltages. As such, the arc will be extinguished at the first current zero and within half a cycle. Because of the rapid recovery rate of the dielectric, the arc, in vacuum interrupter will tend to go out before current zero which will result in an instantaneous current drop to zero and lead to an induced voltage or voltage transient being generated to downstream equipment.

This can be seen by calculating the formula.

$$V_t = IC \times Z_0$$

$V_t$  – Voltage Transient

$IC$  – Current Chop

$Z_0$  – Surge Impedance

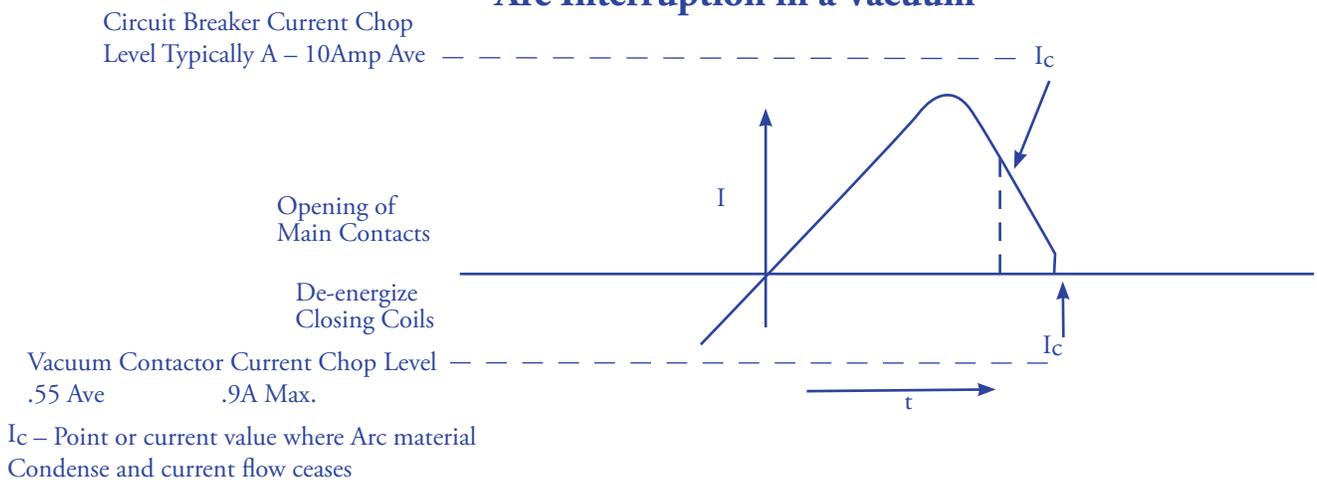
Therefore if the current chop is .9 of an amp and the surge impedance is 3,000 ohm's, the voltage transient will equal 2700 volts on top of the RMS system voltage whether it be 4160 or 5KV. However if the current chop is 5 amps times surge impedance of 3,000 ohms, then the voltage transient can equal 15KV on top of the RMS supply voltage.

You will notice from the above that some assumptions are made with regards to surge impedance values which are difficult to obtain and vary per circuit. In addition, the voltage transient value that a motor or dry type transformer will withstand is difficult to obtain from motor and transformer manufacturers.

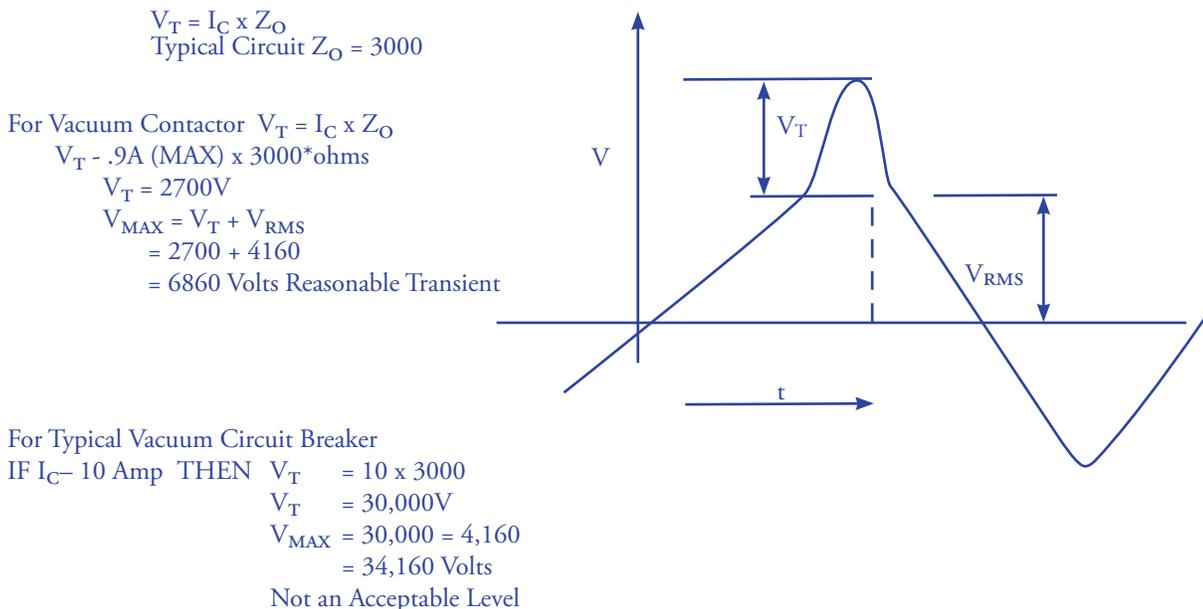
The behavior of materials with different vapor melting points is shown in the attached diagram which highlights the arcing characteristics and how the voltage transient is generated and calculated.

Therefore Joslyn Clark has taken the approach in their designs by the contact material mix gives an interrupt characteristic more than capable of handling the maximum horsepower rating lock rotor currents in terms of interrupt level and keeping the chopping current to an absolute minimum.

### Arc Interruption in a Vacuum



### Voltage Transient



Joslyn Clark is in the business of controlling motors and as such our philosophy has been aimed to satisfy worldwide designs to both North American and International standards.

Over the years this philosophy has proven itself as unlike other manufacturers we have yet to see motor insulation problems created by our contactor. The motors manufactured to NEMA design standards which we consider high class or on motors produced to IEC standards which we consider to be of a lower class, cheaper version.

Joslyn Clark is in the business of controlling motors and as such our philosophy has been aimed to satisfy worldwide designs to both North American and International standards. These days, many installations motors may well be manufactured in third world countries to the cheaper less rigid International standards. Our design philosophy has been well proven over the many years that we have supplied vacuum contactors for a wide variety of industrial and utility applications for motor, transformer loads, or capacitor switching. I trust that the above information explains to you the importance of using properly designed vacuum contactors as opposed to vacuum interrupters that have inherent high current chop characteristics and may be passed off as a vacuum contactor.

Such transients can be damaging particularly to loads like electric motors or dry tape transformers. Transient voltages are controlled by the selection of contact materials. In the case of a vacuum interrupter designed as a circuit breaker which is a device designed to switch high currents infrequently and typically may be rated at 25KA interrupting capability at either low voltage or medium voltage. To achieve this type of interruption the designer must use hard contact material capable of handling extreme high temperatures associated with 25KA interrupt levels. The vacuum contactor designer however whose application as a contactor involves switching motor loads on relatively low currents with possibly a 4 to 6KA interrupt level at either low or medium voltage levels and switch this very frequently.

The designer can use a mix of contact materials incorporating hard contact materials relatively high at vapor melting points and also additional contact materials with lower vapor melting points.

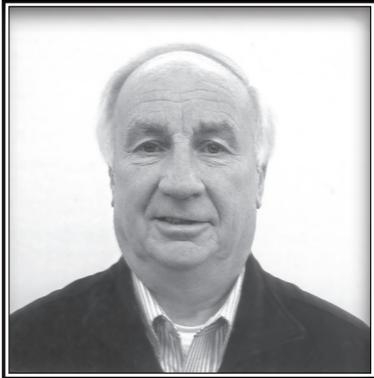
The behavior of materials with different vapor melting points is shown in the attached diagram which highlights the arcing characteristics and how the voltage transient is generated and calculated. However, the higher vapor melting point material which is used for long life and in the case of a circuit breaker higher

interrupter characteristics will condense at a relatively high current and create an instantaneous current zero which will result in a transient voltage. With the introduction of a lower melting point material which can be incorporated in a vacuum contactor then the arc will continue to a much lower current level and minimize the transient voltage.

Some manufacturers claim to have zero current chopping level on their devices and in their publications remain silent on what these levels are. Joslyn Clark has always published the current chop level of our vacuum contactor and expressed it as a maximum current chop as seen 10,000 operational tests. This current level is .9 of an amp and the transient voltage generated can be calculated by the current chopping value IC times the surge impedance Z0 of the circuit. Some manufacturers express current chop levels as low percentages of full load current and as such are acceptable. For example, if you had a 600 amp device, the consider 4 to 5 amps being less than 1% of the devices rating as being acceptable. This is definitely not true as we believe that current chop levels as high as 4 to 5 amps are very dangerous to the insulation level of loads such as electric motors and dry type transformers.

John S. Lett  
Product Marketing & Sales Manager  
Joslyn Clark Controls, Inc.  
Lancaster, SC





*John Lett became involved with vacuum power switching in the early 1960s, soon after completing his engineering studies at Aston University in his native UK. Working on Low and Medium Voltage Contactor and Motor Control Center designs, Lett's work in Engineering, Sales and Product Management developed competitive vacuum designs and expanded their acceptance in European markets. In 1978, he moved to the United States to continue this work in North America, where at the time few manufacturers of vacuum power products existed.*

*Vacuum designs are extensively used today, and at medium voltage almost exclusively used in power switching for motors, transformers and capacitors.*

*Lett retired from JCC/Danaher in 2009, but still works as a consultant for the company. He considers the next step for vacuum products to be utilized in the 10-15 Kv ranges as new motor designs are developed.*