

Application Note AN-112

# Gas Discharge Tube (GDT) Theory



## Construction

Gas Discharge Tube (GDT) surge arresters commonly employ hermetically-sealed enclosures utilizing either ceramic-to-metal or glass-to-metal seals. The many advantages of ceramic-to-metal units have made them the norm for gas discharge tube surge arresters such as those from SRC. Along with being low cost, they offer high product uniformity capable of handling extreme levels of shock, vibration, and temperature.

The ceramic for GDT's is alumina ranging from 94-98%  $\text{Al}_2\text{O}_3$ . The ceramic-to-metal seals are prepared by moly-manganese or tungsten metallizing processes with nickel plating and the final seal is made in a gas-filled vacuum furnace using braze preforms made of copper-silver eutectic. The electrodes used for GDT's are either copper or a nickel-iron alloy, often with a coating to lower the work function and/or add gettering capability. Stripes or bands of semi-conductive material are applied to the inner surfaces of the ceramic to improve stability and high-speed response.

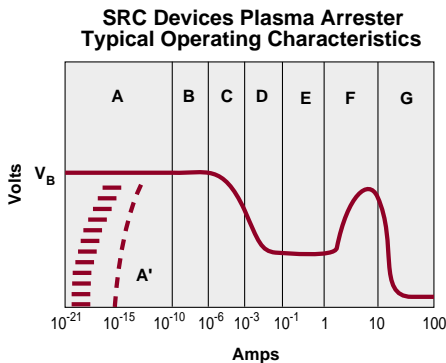


Figure 1. A generic V-i characteristic of a plasma device.

## Theory

The basic operation of gas tube surge arresters such as SRC GDT's is best understood by referring to the schematic form of the voltage-current (V-i) relationship of a generic gas discharge device such as the one depicted in Figure 1.

### Description of Regions of a Generic V-i Characteristic of a Plasma Device

- A For voltages below the breakdown voltage, the gas provides a good insulator. Very low leakage currents ( $10^{-12}\text{A}$ ) occasionally encountered result from ionization by cosmic rays, high energy photons, etc; and is, therefore, subject to statistical fluctuations.
- A<sup>1</sup> The current is higher due to supplementary electron sources such as photoemission.
- B The discharge is self-sustaining due to gas ionization –if external agents such as those mentioned for regions A and A<sup>1</sup> are removed, the current will not change (Townsend discharge). This occurs at the breakdown voltage of the device.
- C The transition region. As the electric field increases, more secondary electrons are generated, decreasing the voltage drop until the glow voltage (region D) is reached. Stable operation can only be maintained with active current regulation because of the negative slope of the V-i characteristic.
- D The glow region (or normal glow region). In this region, the glow voltage is roughly constant with respect to small changes in current.
- E The abnormal glow region. In contrast to the normal glow region, the glow voltage begins to increase as the current is increased.
- F The glow-to-arc transition region.
- G The arc region. In this region, the arc voltage will quickly drop and the arc current will quickly increase within the limitations of the drive energy and impedance.

If the current through the gas discharge device is adjusted over the range of values of  $10^{-18}$  to  $10^2$  amps, the voltage across the device will also vary. When a gas discharge device is operated as a transient voltage protector, the modes of operation of greatest significance are in regions A, F, and G. The applied voltage is normally less than the breakdown voltage of the device,  $V_{BD}$ , at which time the current through the device is in the A region. The charged carriers of electric current in this mode originate from the cathode by photon emission and within the fill gas by collisions of gas particles with cosmic rays (or radioactive decay particles if an isotope is used in the device).

As soon as the applied voltage across the device exceeds the breakdown voltage, the current through the device increases rapidly to values of several amps or greater. The rate of current rise and the level reached is limited by the source capacity and the series impedance of the circuit. The voltage across the device at this time is very low with typical values of 20V or less.

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