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Technical Tidbits

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So what is an arc, anyway? This issue of Technical Tidbits is an overview of arcing in separable electrical connectors.

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The next issue of Technical Tidbits will discuss the effects of arcing.

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Introduction to Arcing Contacts

Technical Tidbits has spent many months describing material and design issues for separable electrical and electronic connectors. This months edition will focus on a special class of separable connectors - those in which there is a potential for arcing. Make and break contacts such as switches and relays must repeatedly establish and break contact within electrical circuits. In an ideal world, the current would flow when the circuit is closed, and would immediately cease as soon as the contacts separated. Unfortunately, the universe does not care much for ideal situations.

Arcing is a very complicated subject that is continuously being studied. A good reference for those who wish to learn more about arcing is Electrical Contacts, Principles and Applications, edited by Paul G. Slade, published by Marcel Dekker. It devotes over 400 pages to arcing and arcing contacts. However, even these 400-plus pages can be considered to be merely a brief overview of the subject.

Arcing is a phenomenon by which current can travel across a gap between electrically charged surfaces (such as the two contact surfaces on a separated electrical connector). It can occur in closing contacts as the two surfaces approach each other, before the two halves of the interface actually touch. It also can occur in opening contacts as the two contact surfaces separate from each other.

An electrical connector or switch must pass current across the contact interface when in the mated or closed position. This means that there is an electrical potential (voltage) across the contact interface. When a connector is unmated, or a switch is opened, the current may stop flowing, but the voltage still exists. This potential will only go away if the source voltage in the circuit is disconnected. Under the right circumstances, this voltage may induce an arc across the gap between the contact surfaces.

Arcs can only ignite when the electrical potential between the two contacts exceeds the **minimum arc voltage**, and the available current in the circuit exceeds **minimum arc current**. These are not absolute values, but depend on many factors such as the contact interface material, distance between the contacts, and the medium between the contacts. They also are functions of each other. If the source voltage in the circuit is increased, then the minimum arc current drops. If the available current in the circuit is increased, then the minimum arc voltage drops. *However, if either the voltage or current drops beneath the minimum level, the arc will cease to burn.* This does not preclude the possibility that the arc may reignite later. In DC circuits with inductive loads, the arc may extinguish and reignite several times. This is known as a **showering arc**.

Arcing can occur upon both the opening and the closing of a contact interface. In the closing case, the minimum arc voltage drops as the two contact surfaces approach each other. If the source voltage is too low, no arc will form, and the current will only start to flow once the surfaces are in contact with each other. With sufficient source voltage, a **closure arc** will occur when the minimum arc voltage drops below the source voltage.

A closure arc begins when electrons leave the cathode and jump across the contact gap to the anode. Along the way, the electrons will collide with and ionize gas molecules in the air. (The glow of the arc comes from the energized gas molecules.) As the electrons rain upon and heat the anode, it may release positive ions into the gap. These positive ions, along with those created in the intervening gas, will likewise bombard and heat the cathode. This heating may vaporize portions of the anode or cathode, resulting in wear. Together, the electrons, metal ions, gas ions, and vaporized metal form the **arc column**. A typical arc column is schematically (albeit simplistically) illustrated in Figure 1.

Arcing can also occur when the two halves of the contact interface separate, breaking the current path in the circuit. This occurs when large current and voltage loads are interrupted, as are usually found in switches and relays. However, this can happen when in other separable connectors, such as automotive wire harness terminals, if the circuit is not de-energized prior to separation of the connector.

Opening arcs can initiate in a different way. As discussed in prior editions of Technical Tidbits, any two surfaces in contact touch each other only at their high spots, or asperities. There is a certain amount of electrical resistance as the current is “squeezed” through these small numbers of paths across the interface. As the contacting surfaces begin to separate, the asperities decrease in both size and number. This forces a greater amount of current through each asperity and increases the electrical resistance. Resistive heating eventually will cause the last few paths to melt, resulting in a current-carrying molten metal bridge between the contacts. The bridge will vaporize at temperatures high enough to release electrons, initiating the arc.

Of course, arcing has consequences for the performance of the contact interface. This will be discussed in the next edition of Technical Tidbits

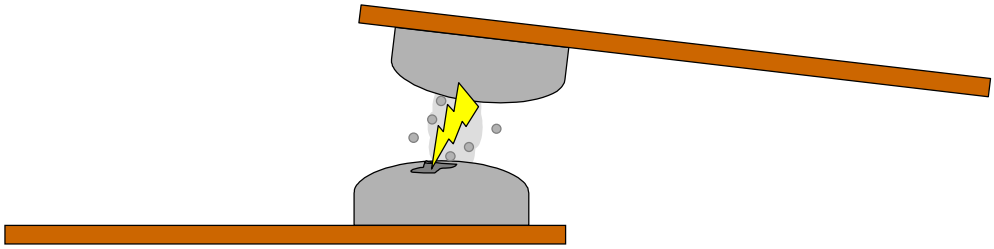


Figure 1.- Arcing representation, showing arc, plasma column, metal vapor, and electrode wear.

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