Electrical Terminals

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Insulated and non-insulated closed barrel electrical terminals and splices have been around since the early '40's. They originated from the need for a solderless method to terminate wires in military equipment. From those modest beginnings, electrical terminals have grown into a major interconnect product class. Applications of these products are very diverse. Many insulated terminals and splices are used in household appliances. Other OEM products containing terminals and splices are airplanes, rail cars, industrial control systems, recreational vehicles, blenders, irons, coffee pots, power supplies, industrial machines, communications equipment and many, many other applications. Just about any application that must connect discrete wire in a point-to-point configuration is a candidate for an electrical terminal or splice.

Insulated and non-insulated closed barrel electrical terminals are connectors that link a wire to an electrical component. The component may take on a number of guises: posts, tabs, lugs, pins, terminal blocks or other designs. The terminal attaches to the wire mechanically via a crimp to make the electrical connection.

Terminals, depending on the style, are available with many different connecting interfaces. Popular connecting interfaces include ring tongue, rectangular tongue, spade tongue, spring spade, slotted ring tongues and several others. The connection interface (i.e. ring tongue, spade, etc.) however, is not the only difference between terminals. Several styles prevail.

The most is SOLISTRAND. This product is a stamped and formed terminal, with a brazed seam. These terminals are tin plated. Insulated electrical terminals are commonly called "RBYs". RBY has evolved into a term that describes a wide range of insulated crimp style electrical terminals and splices. The R, B and Y stand for the basic colors, red, blue and yellow, of the insulation on insulated terminals and splices. The colors identify the wire range the terminal can accept: generally 22-18 for red, 16-14 for blue and 12-10 for yellow.

A basic insulated version, such as PLASTI-GRIP will have features that provide insulation properties and sound electrical connection. One important feature would be a funneled wire entry to avoid wire stubbing. The inside of the wire barrel would be configured to provide good tensile strength while maintaining maximum contact with the wire. A designer would select this product in applications where a basic insulated terminal was required. Products in this category generally carry agency approvals; UL 486 and CSA 22.2 No. 65 are typical. These basic terminals usually accommodate wire sizes from 22 AWG up to 2/0 AWG. A real-world application of this product style could be found in a vacuum cleaner where the power cord is connected to the motor.

The next level, such as PIDG, would have additional features. These terminals are designed for more rigorous applications. Again, these terminals retain the color-coded insulation and wire entry funnel. A metal sleeve is added to the design to provide additional rigidity and robustness for applications that experience mechanical shock or vibration. The sleeve lies between the metal terminal and plastic insulation. The wire range this product accepts is usually 26 AWG up to 10 AWG.

This style of terminal is suitable for many rigorous applications and can still be found in military equipment. In fact, some of these terminals meet SAE AS7928 Type II Class 1 and Class 2 (Formerly MIL-T-7928 Type II Class 1 and 2). Other applications may include fighter jets and attack helicopters.

Other insulated electrical terminals are available. Typically, though, they are designed for less mainstream applications. These special versions can include larger wire sizes (e.g. 8 AWG through 4/0 AWG), higher temperature ratings and more rugged designs with improved strength of the terminal.

Materials

The combination of the terminal’s metallic component and a good crimp can provide a connection that is said to be electrically “invisible”. This essentially means that the system, either power or signal, is not impacted by the terminal as there is little electrical resistance at the connection between the wire and the terminal. The base material used in insulated and non-insulated terminals and splices is usually copper. Copper provides superior conductivity, requires low cost stamping tools, is easy to electroplate and requires low crimping force. Occasionally, as in the case of a spring spade tongue terminal, phosphor bronze is used to maintain certain spring properties in the terminal. Tin plating is normally used on most terminals for its corrosion resistance and ability to ‘wipe’ contaminants from the bare wire during the crimp process.

However, terminals used in military and aerospace applications may employ tin-lead plating. The plating on the metal sleeve used in the higher-end products typically matches the plating on the terminal body.

Insulation materials differ from the basic terminal version up to the more advanced designs. Typically, to keep costs down, the basic terminals use vinyl insulation. Vinyl provides good dielectric strength and supports the wire insulation. Higher-end terminals use nylon insulation which has good dielectric properties and does not out-gas like vinyl – a critical factor in aerospace applications. Furthermore, nylon is resistant to hydrocarbons like gasoline, hydraulic fluids and oils. Other insulating materials include TEFLON and PVF II. TEFLON is an emerging insulator for electrical terminals. It would be specified when the application has high ambient temperatures (vinyl and nylon are suitable up 105 deg. C). TEFLON insulation, on the other hand is suitable up to 260 deg. C. PVF II can be specified for applications with a maximum temperature range of 150 deg. C.

The Crimp

The heart of any good solderless terminal system lies in the crimp system used. This may sound simple, but to maintain electrical integrity, tensile strength and insulation properties, a sound crimping technique and system must be used. The first thing to consider is that a good crimp relies on the wire, the terminal, and the tool. If any of these items are out of the terminal manufacturer's specifications, an unacceptable crimp may result.

The crimped interface between the wire and the terminal is considered a high-pressure, permanent connection. Again, each component of the crimp (wire, terminal and tool) contributes to the integrity and the performance of the connection. An integrated crimp 'system' helps a given terminal meet the stringent conditions of agency approval and requirements of UL, CSA and military specifications. At Tyco Electronics, for example, crimping technology is designed to produce numerous cold welds between the wire and wire barrel that renders a nearly invisible electrical connection. A cold weld site occurs when sufficient pressure is applied to two small, but distinct, metallic surfaces already in intimate contact. Without sufficient cold weld sites, a condition known as "static heating" prevails. Static heating is a self-perpetuating phenomenon that occurs as follows:

Crimping takes advantage of work hardening the copper wire barrel to hold the wire in place. Mild heating of the crimp begins to stress-relieve the crimped area. When stresses are relieved, cold weld sites break. Broken cold weld sites increase the resistance between the wire and wire barrel. This, in turn, increases the temperature in the crimp area; further stress relieving the crimp. This scenario continues until the crimp area becomes overheated and may result in melted or burned insulation.

Why Crimp?

Crimping can be used in the vast majority of terminal to wire applications. While other methods are considered strong mechanical connections with high-performance electrical properties, crimping provides strength under constant load in tension and severe vibration. Crimp connections tend not to crack or creep under sustained loads. Fatigue is not an issue. Since the mechanical performance of a crimp is robust and sound, the electrical properties are less likely to degrade. In short, static heating is avoided when good crimping practice is followed.

One reason to use a terminal is its performance. Ease of assembly to the wire is another important issue to explore. Crimped terminals can be assembled with several levels of automation. From manual hand tools to power-assisted hand tools on up to semi-automatic bench crimping machines and complete harness making machines, there is an ever-increasing list of options to crimp terminals. Most crimping tools and machinery provide repeatable, low labor content results. Hand tool crimp production rates of up to 60 CPH (Crimps Per Hour) versus thousands of CPH with power assisted tools. Some machines even integrate several processes into one system (e.g. Wire preparation like cutting and stripping).

Crimped Connection Myths

"Soldering or Solder-Dipping Will Improve the Connection"

Crimps are designed to work without solder or solder-dipped wire. When solder is present in a crimp, the deformation properties change. This change impacts metal-flow, cleaning, cold welding and residual forces and compromises the mechanical and electrical properties of the crimp. With diminished mechanical properties, the connection may not survive normal uses. Furthermore, as electrical performance diminishes, the perils of static heating arise. Additionally, in some cases, copper wire may become embrittled or solder wicking may affect the flexure strength of the stranded wire. By soldering a crimped connection, the process heat may compromise the crimp.

Summary
Insulated and non-insulated terminals and splices play an important role in many electrical devices. Their reliability, performance and low cost result from the design relationship between the wire, terminal and tool. The terminal and splice bond to the wire makes electrical connectors suitable for many applications. By getting back to the basics, designers will likely find a suitable insulated terminal that meets their reliability, performance and cost requirements.

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