CRIMPING TERMINALS

The importance of using the right tool

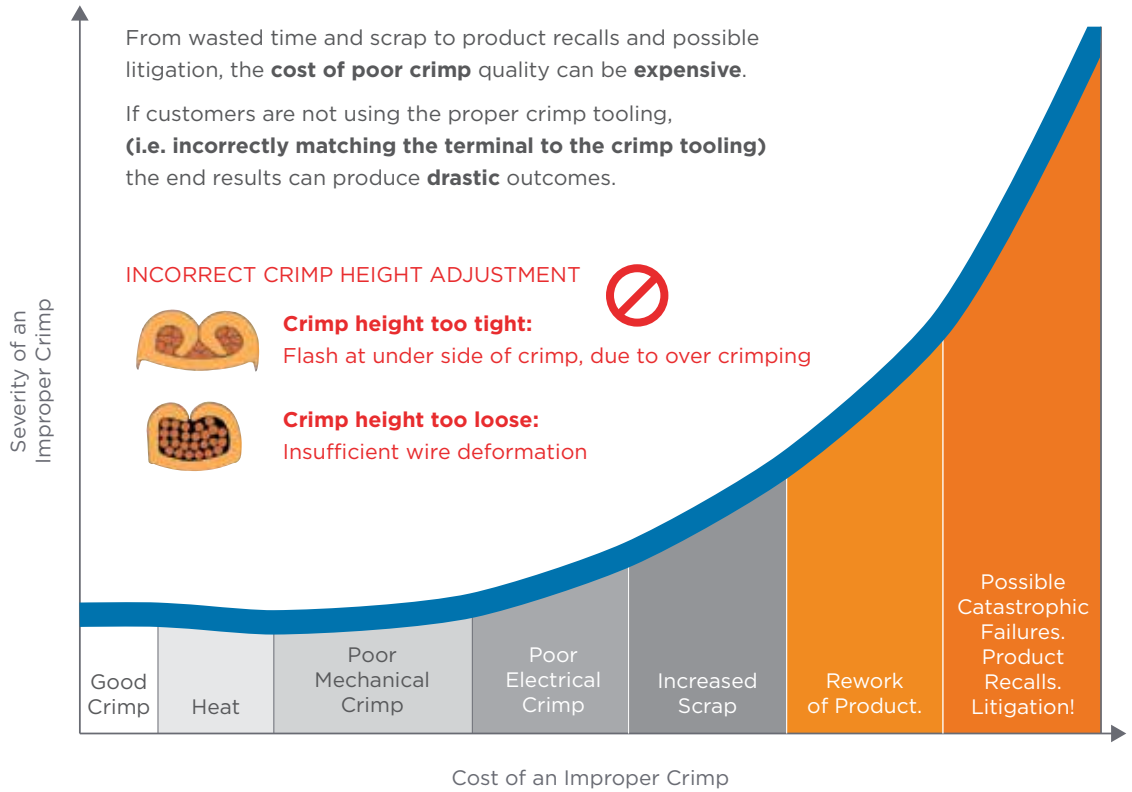
There are few things in the world of electrical assembly that appear more straightforward than crimping wires to terminals. Stripped wire is inserted into a short metal tube called a wire barrel. A crimping tool then compresses the wire barrel tightly around the strands of the stripped wire, forming one homogeneous metal. No solder, heat, or flux is needed, and the job is done in moments. Its simplicity is why the solderless terminal remains one of the most popular connectors on the market for more than seventy years.

Solderless terminals are one of the lowest cost components in a system, but the repercussions of a bad crimp can be crippling. There is much more complexity to the process than meets the eye. Unfortunately, many people in the industry overlook the fundamentals of a good crimp and unknowingly put the integrity of their products at risk. One guiding principle needs to be followed to ensure a good crimp – tool and terminal must come from the same manufacturer.

Bridging the knowledge gap

Most people think they can use any tool to crimp a terminal. If after a brief visual inspection, the terminal looks good, they assume the connection is secure. However, crimping solderless terminals is a carefully engineered solution, and looks can be deceiving. A single bad crimp can cause both physical and electrical problems. If the crimp is not properly formed into one homogeneous metal, the electrical connection is prone to high electrical resistance and/or failure. In addition, the physical connection can be broken when exposed to even the most minor stresses. Any of these issues will cause the product to malfunction or fail, resulting in lost production time, damage, repairs, and potential injury or litigation. See our Crimp Tooling - Where Form Meets Function publication on TE.com for a more in-depth look at crimp fundamentals.

Dangers of Improperly Crimped Terminals



Optimizing Crimp Performance

Tool and terminal are carefully engineered to act in tandem, creating crimps that optimize electrical and mechanical performance. A connector engineer configures the crimp profile (crimp height and crimp width) to achieve the desired form of the wire and wire barrel when formed into one homogeneous metal. Too loose a crimp will result in poor mechanical performance and electrical conductivity. Too tight a crimp may improve electrical performance up to a point, but can damage the terminal body or wire strands, causing a reduction in crimp tensile strength and/or vibration resistance.

Figure 1 illustrates the tradeoffs when designing a crimp. The shaded grey area is the range of crimp profile configurations that optimize electrical and mechanical performance. Crimp design is a meticulous process that takes years of experience to perfect. Tools and terminals from different manufacturers are not engineered to work in tandem, and therefore crimp performance cannot be guaranteed.

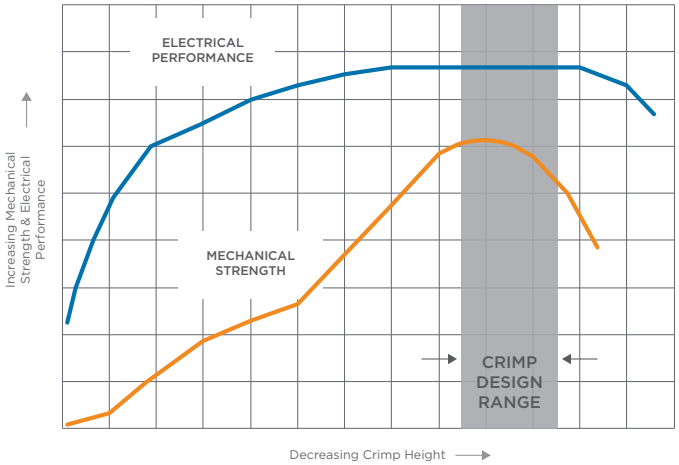


Figure 1 – Correct Crimp design takes account of materials, dimensions, and terminal characteristics, for optimum electrical and mechanical properties

Performance Testing for Industry Certifications

Manufacturers use industry standards developed by safety and certification agencies like UL, CSA, and the United States Department of Defense (military specifications) to ensure safety and performance of electrical products. Some standards apply specifically to solderless terminals, while others pertain to the products powered by them. Products are tested in a controlled lab environment according to a set of detailed instructions and criteria. If the product performs within a strict range of acceptable outcomes determined by the agency, it becomes certified. Solderless terminals go through a variety of tests to certify their electrical, mechanical, and physical integrity. Several tests typically required for industry certification are described below.

Vibration Testing

A crimped terminal or splice is mounted between two poles – one pole vibrates and the other remains a stationary support. The specimen must not show signs of electrical discontinuity, cracking, breaking, loosening of parts, or other physical damage after typically 18 hours of exposure to intense vibration.

Figure 2 – Military Vibration Test - SOLISTRAND Splices

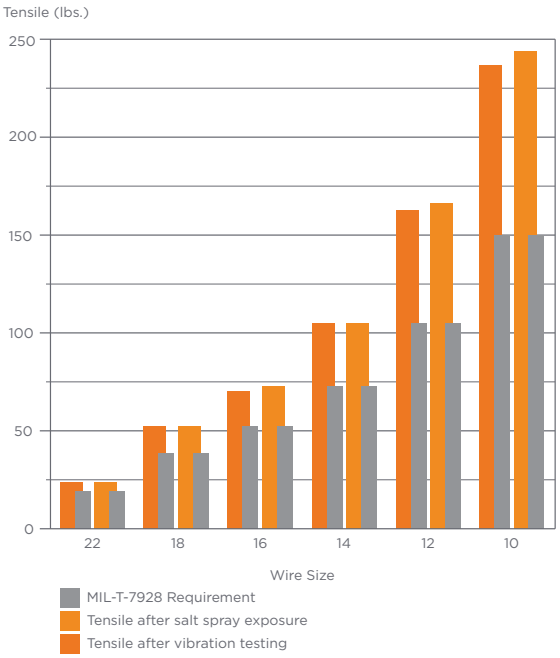
Figure 3 – Military Vibration Test – PIDG Terminals

Crimp Tensile Strength Testing

A crimped terminal or splice is mounted on a test system by securing the terminal in a clamping fixture attached to a tensile testing machine. The system applies a linear pull on the test specimen at constant applied force until the crimp fails. The wire must not pull out, break, or separate from the crimp before the minimum crimp tensile strength requirement is met.

Figure 4 – Crimp Tensile Strength Test – Diamond Grip Butt Splice

Figure 5 – Crimp Tensile Strength Test Results - SOLISTRAND



Dielectric Strength Testing

This test measures the effectiveness of the insulation of a terminal. A crimped terminal is dipped in molten insulating wax that covers and seals the exposed end of the terminal, but not high enough to cover the crimp area. The waxed end of the terminal is embedded in lead shot, deep enough to cover the crimp area. Voltage is applied between the loose wire end and the lead shot. The terminal insulation must withstand the exposure without showing signs of flashover or physical damage.

Figure 6 – Dielectric Strength Test – PLASTI-GRIP Terminal

Voltage Drop Testing

Voltage drop is defined as the amount of voltage loss that occurs through all or part of a circuit. It is an indicator of electrical resistance and stability of crimped terminals when exposed to a specified current. This test measures the level of homogeneous mass achieved during the crimping process where the sum of the two masses' resistance, the wire barrel and stripped wire, is less than the total of the individual components' resistance. Crimped terminals are bolted together in a series chain and exposed to a test current. The voltage drop must be within a specified range, based on wire size and test current, to achieve a passing grade.

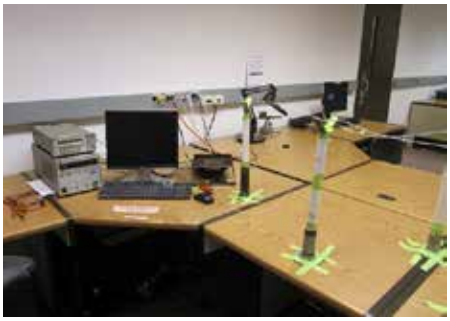


Figure 7 – Millivolt Drop Test – SOLISTRAND

The Misinterpretation of Industry Certifications

Unfortunately, companies that use solderless terminals routinely misunderstand agency certification criteria, and unknowingly put their own products at risk. According to the certification criteria for solderless terminals, all crimps must be created using tools and terminals from the approved source. If a terminal is not terminated with the tooling as noted in the associated report, it is not considered approved since all testing and evaluation of the terminal by the certification agency was done in conjunction with the specified tools. From the certification agency's perspective, use of different tools could result in different test results.

For example, a UL certified crimp requires a UL certified terminal and the associated UL certified tool. Military certifications are divided into two classes. Class 1 terminals and crimp tooling must conform to the military dimensional and performance specification. Class 2 terminals and crimp tooling consist of the terminal manufacturer's approved application tooling, with dimensional requirements specified by manufacturer's drawings, and the specific terminals that meet the same performance requirements as Class 1 parts.

When tools are incorrectly matched to terminals, the geometric relationships between the anvil, terminal, and crimper do not align correctly. Typically, the wire barrel does not properly form into the stripped wire, the terminal body twists or bends, and/or the wire insulation gets damaged. Often invisible to the naked eye, these defects yield crimp connections of inferior electrical conductivity and physical integrity.

A Crimp for the 21st Century

We are entering a new era called Industry 4.0, where new trends and innovations like the Industrial Internet of Things (IIoT) and machine learning combine with advancements in robotics and automation technology to forever change the way things are made. Manufacturing processes communicate with each other and adjust in real time with minimal human input. Machines run longer, maximize throughput, and produce more efficiently than ever before. That means component parts must be designed to keep up. In the 21st century, customers demand rugged, long-lasting products able to withstand vibration and harsh environments.

Backed by decades of engineering expertise, TE has a successful track record of introducing the newest and most innovative crimp technologies to market, like the DIAMOND GRIP anti-vibration insulation support sleeve, OCEAN applicator series, and the TE CrimpData app. TE terminals and splices are proven to meet the needs of today's market. Most product meets or exceeds commercial and/or military certifications. In fact, safety and certification agencies come to TE for input when developing new standards for the industry.

SOLISTRAND terminals and splices offer superior performance characteristics while terminating solid wire, stranded wire, or irregular shaped conductors. These brazed-seam uninsulated lugs are engineered to ensure reliable and long-lasting performance in the most punishing environments. SOLISTRAND is designed for an estimated 40-year electrical service life based on millivolt drop testing results. SOLISTRAND is corrosion resistant, vibration resistant, and has a tensile strength that easily meets UL, CSA, and military specifications when applied with corresponding approved tooling.

PLASTI-GRIP pre-insulated RBY (red, blue, yellow) terminals and splices are designed to answer the need for low-cost insulated electrical terminations. They consist of a high-conductivity copper body and PVC insulation. The wire and wire barrel together form a connection of high conductivity and tensile strength, while the tin plating provides good resistance to corrosion. PLASTI-GRIP is color-coded by wire size, and corresponds to compatible tool cavities for easy crimp cavity identification during crimping. With over seven billion shipments to date, PLASTI-GRIP is the industry standard choice for all commercial applications and most are UL and CSA approved when applied with corresponding approved tooling.

PIDG (Pre-Insulated DIAMOND GRIP) terminals and splices are designed for complete and uniform reliability in the most difficult circuit environments. Proudly serving customers for 75 years, PIDG has an added copper sleeve that crimps to the wire insulation for strain relief support. This unique design provides maximum vibration resistance and allows the wire to bend in any direction without damaging the wire insulation or conductor, and they also have an estimated 40-year electrical service life. PIDG comes in Nylon, PVC, or Radiation-Resistant insulation options. PIDG insulation is color-coded by wire size, and corresponds to compatible tool cavities for easy crimp cavity identification during crimping. Most PIDG product is UL, CSA, and military approved when applied with corresponding approved tooling.

Save on Applied Costs with TE Tooling

As advancements in automation continue to push throughput levels to an all-time high, the Total Applied Cost of crimping terminals to wire is fast becoming a critical factor when designing successful wire crimping solutions for solderless terminals. Total Applied Cost refers to all costs associated with crimping wires to terminals. It factors-in both the first-time equipment costs, as well as the long term indirect expenses involved in the purchase including wire cut and prep, labor, maintenance, rework, and material costs. Every manufacturing process is unique, so Applied Costs vary drastically based on volume or throughput needs. Imagine the Applied Cost of trying to crimp thousands of terminals a day with just one hand tool.

TE's team of Field Engineering Service Specialists work with customers to provide expert guidance in creating custom wire crimping solutions that maximize throughput and optimize Applied Cost. Most manufacturing companies have fewer productive machine hours than they realize. In many cases it is possible to gain an additional 20 - 60% of productive time each day by selecting the right tooling and making basic changes in process, training, and/or equipment. The Field Engineering Service team is available upon request for on-site training, preventative maintenance, hand tool calibration, and support for TE tooling customers.

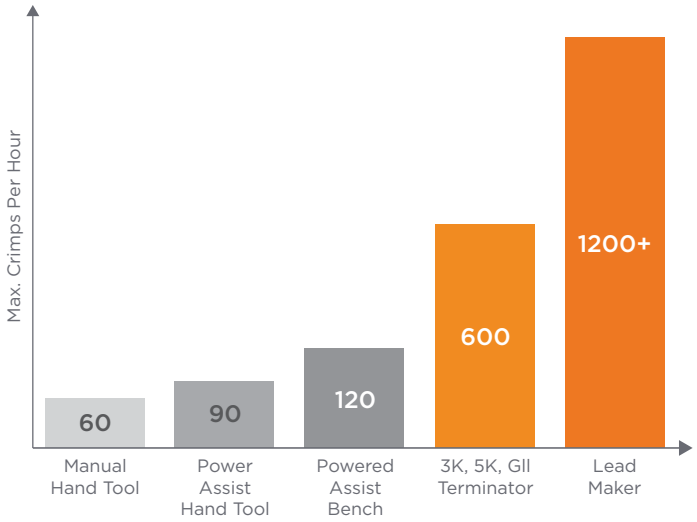
20-60%
MORE PRODUCTIVE

Did you know that in many cases it is possible to gain an additional 20 - 60% of productivity time each day per installed lead maker by instituting basic changes in people, training, processes and/or equipment.

The Power of Automation

TE offers a wide range of tooling options to meet the ergonomic, wire size, and production volume needs of its customers. Its equipment and services are designed to maximize production uptime, extend tooling life, and minimize manufacturing waste. Whether production involves a few prototypes in the lab or thousands of leads a day, TE has a tool for every step along the way to fit evolving production needs. The company's interchangeable Standard Die Envelope (SDE) allows users to continue using the same die sets across multiple tooling platforms. All TE die sets feature high quality materials and surface treatments for long lasting performance. TE applicator dies typically do not show signs of wear until 300,000 cycles or more.

The following chart is a guide for when customers should step up to the next tooling level based on the number of crimps or leads they are producing per hour.



TE tools are designed with crimp specification, quality, repeatability, and ease of use in mind. Features like the CERTI-CRIMP terminal locator and the Crimp Quality Monitoring (CQM) system make it easy to set up and control crimp dimensions, resulting in repeatable high-quality crimps, giving peace of mind to even unskilled tool operators.

Conclusion

Crimping wires to terminals is not a “one size fits all” process; it is a carefully engineered solution – terminal to tooling. In fact, solderless terminals are designed to perform as specified only when crimped by tools from the same manufacturer. If the tool and terminal are not from the same manufacturer, the crimp will not meet industry certifications because the quality of the connection cannot be guaranteed. Defects may not even be visible to the naked eye. Taking the time to select the proper tool and terminal ensures lasting crimp performance, saving customers time and money. To learn more about our various tool and terminal products, contact TE today.

Additional Resources

Check out our Crimping Fundamentals video here.

Check out our entire portfolio of Terminals and Splices here.

Visit our Tooling Homepage to find the right tooling solution for you.

Visit our Industrial Terminals and Splices Homepage for product information.

Get Connected

Click the Live Chat button on TE.com to connect with a Product Information Specialist or call the Customer Service numbers below:

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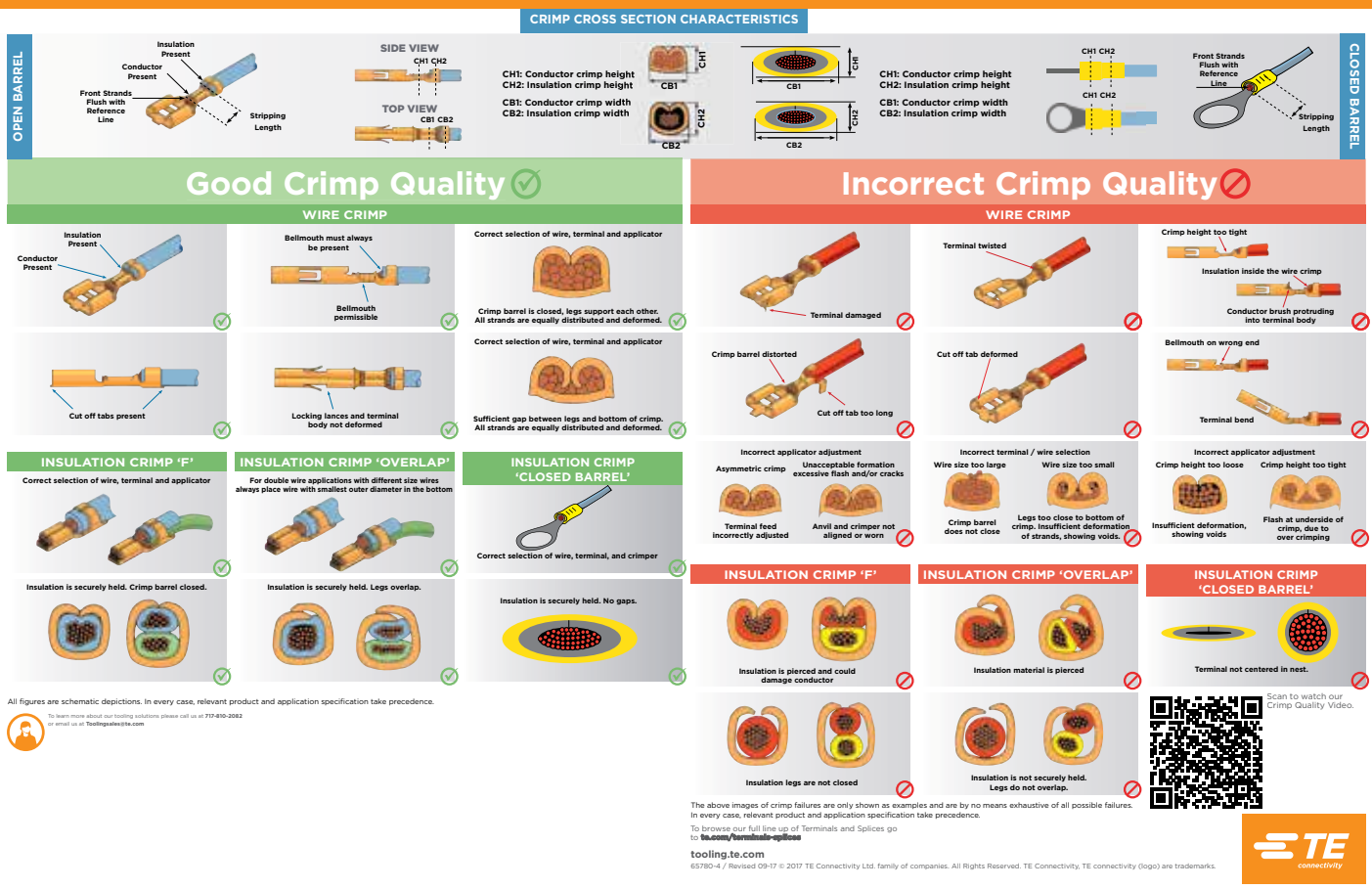
CRIMP QUALITY GUIDELINES



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