# Crimp Height—

## Employing the Most Effective Crimp Quality Metric for Meeting Contemporary Quality Standards

*Driven by the requirements of 6-Sigma and other international quality standards, TE has developed crimp testing technology that provides dependable, non-destructive, evaluation of 100% of crimped terminals without impact on production throughput. Crimp height measurement is a well-established methodology and, in combination with crimp force measurement, is superior to destructive methods, sampling methods, or techniques that depend on crimp force alone. Crimp height has been demonstrated to be an effective measure of the quality of the crimped-on terminal. Crimp height measurement combined with crimp force is a powerful tool that can detect assembly issues as well as tool wear and other process defects.*

### Connector Design Factors

When a connector design engineer begins to design a crimp, several things are considered, including the size and composition—solid/stranded/aluminum/copper, etc.—of the wires to be crimped, and the required electrical and mechanical properties. After optimizing to obtain the best results in both these properties, the engineer determines the best crimp profile and the appropriate crimp height range and width, to achieve the desired reduction in the area of the wire. Deviations from crimp height standards can result in degradation of either mechanical or electrical performance.

A loose crimp will result in poor mechanical qualities, and likely, poor or noisy electrical conduction. Too tight a crimp may improve the electrical properties up to a point, but mechanical properties may suffer as a result. Individual wire strands may get cut or the wire may start to undergo excessive plastic flow, leading to a reduction in crimp tensile strength or vibration resistance. Figure 1 illustrates the tradeoffs in optimizing crimp design and how crimp height is an accurate measure that combines both electrical and mechanical performance.

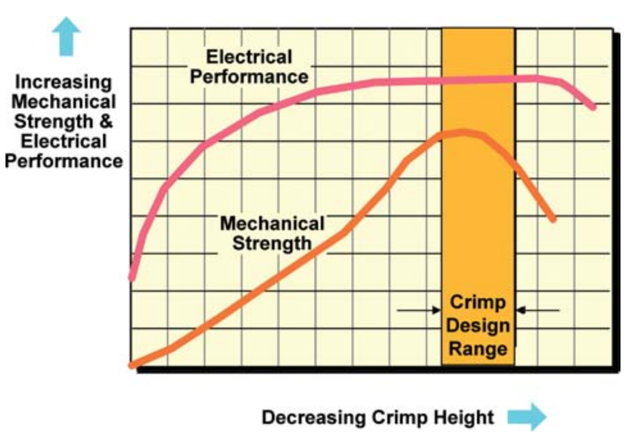



**Figure 1: Correct connection design takes account of materials, dimensions, and terminal characteristics, for the optimum electrical and mechanical properties of the crimp.**

### Comparing Crimp Quality Measurement Technologies

It is common to measure pull-out force as a basic criterion for crimp quality. Indeed, it checks the mechanical properties of the crimp. However, as discussed above, too tight a crimp can be as bad as one that is not tight enough. Pull-out force may not be sufficiently sensitive to detect over-crimping in cases where the process has not gone so far as to break the wire or terminal. A crimped terminal that passes the pull-out test may nonetheless have a reduced lifetime or resistance to subsequent damage from handling, installation, or vibration. Of course, since it can be a destructive test, it may be performed on a sampling basis, only. This sampling still provides an auditable quality record.

Crimp force has also been employed. Strain gauges or other force sensors appropriately mounted can acquire force data. Specifically, force during the crimp and the peak force are evaluated in relation to average and standard deviation specifications and, as soon as a crimp cycle occurs in which the value of either exceeds a preset multiple of the standard deviation, the termination is evaluated for faults. This test does allow 100%, non-destructive testing, but does not validate the crimp to the original terminal design intent.

Crimp height, as illustrated in Figure 1, is also a common measurement. Crimp height can be used to validate crimp to original design intent but by itself, crimp height can not discern process variables such as wire and terminal variation. As a standard, this measurement can be performed with a vernier caliper fitted with appropriate jaw modifications. As such, of course, it is useful for standardizing but is too slow for 100% production inspection.

The best method to validate crimp quality is to use a combination of crimp force and crimp height. This results in being able to confirm the achievement of the terminal design intent as well as discerning wire and terminal variables that can result in poor terminations.

### Practical Measurement of Crimp Height

Clearly, the ideal situation for production is 100% testing without any impact on throughput. Such an approach avoids any sampling error, and allows process adjustment as the production run progresses. Over a decade ago AMP Incorporated (now TE Connectivity) introduced a patented system (US Patent No. 4,867,186 and others ) that monitors parameters that can be used to calculate crimp height during the final phase of each crimp cycle.

In this Crimp Quality Monitor (CQM), a solid state position sensor is installed in the terminator, with a force transducer assembled into the ram or base plate, with both monitored by a control unit attached to the terminator. The resulting signals are transmitted to the microcomputer in the CQM system, where the crimp height is calculated. The height is determined as a function of ram displacement and crimp force through a complex algorithm, which also takes account of the effects of friction. The critical point of measure is where the "retreating" ram experiences zero force, representing the point where the terminal ceases to spring back.

See Figure 2 for a typical force signature, showing the force vs. ram position during a crimp cycle. The area within the curve represents the energy in the permanent deformation of wire and terminal.

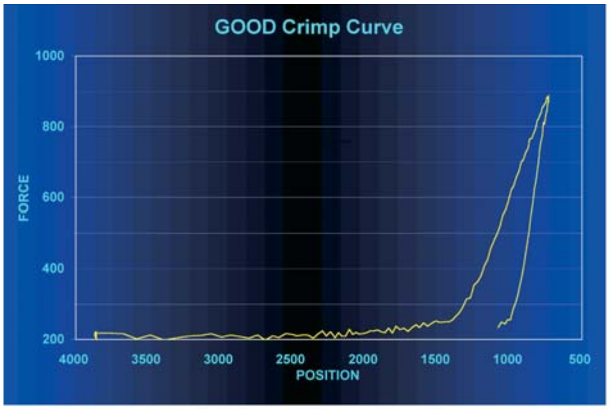


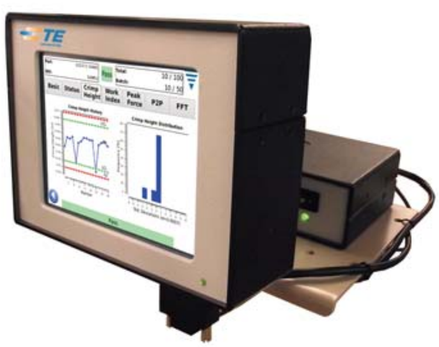

**Figure 2: The force signature is a real time picture of the crimping process.**

Once the CQM is calibrated, it can display the measured crimp height with an accuracy of ± 0.013 mm [± 0.0005 in] for base plate mount or ± 0.005 mm [± 0.0002 in] for ram-mounted sensor).

## An Accurate, Practical Tool

The basic technology of crimp height measurement in a working environment calls for a convenient, traceable calibration method and effective data management, display, and communication.

The CQM is designed for operator convenience and operational versatility, with a touch screen for control and display.



**The CQM II is a compact, easy-to-use tool for tracking crimp height, monitoring the process, and generating the data necessary for 6-sigma and other statistical compliance measures.**

## Calibration

Calibration is performed for each new part type by measuring a crimp and then by performing a visual inspection for acceptability. If acceptable, this becomes the nominal value. A subsequent calibration run of a predetermined number of crimps provides the statistical limits for the full run. Tolerances, size of calibration run, run and batch size, and product identification are all entered on screen, for auditable control of the run.

### Data Management, Display, and Communication

All functions are controlled through the touch screen, with an easy-to use graphical user interface. When numeric or alphanumeric input is required, an appropriate keypad or full keyboard appears on the screen (See Figure 3).

During a run, detailed data can be observed on screen, including curves of force vs. position, force vs. time, and position vs. time (See Figure 4). On some applicators, sequencing through the run is also displayed, either for single parts of for components within a kit. A simple Good/Bad indicator cues the operator for action. Measurement data also can guide the operator to correct problems in wire placement, stripping, or tool wear. Bar graph displays give a visual indication of crimping quality (See Figure 5). Production and quality managers have full remote access to the CQM through a web interface, including statistical data, software and memory information, and production parameters. Depending on batch parameters, setup information and data can be stored within the unit for operational flexibility and subsequent analysis.

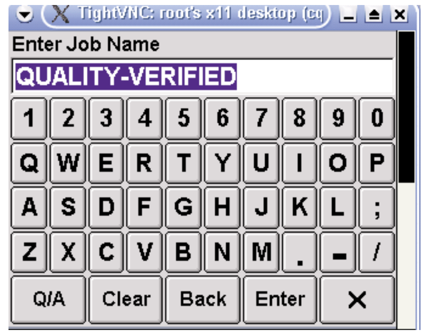



**Figure 3: A full alphanumeric keyboard shows on screen when needed for data entry.**

For compatibility with a fully integrated production environment, the CQM communicates through an Ethernet connection to the network. Management functions, including data monitoring and data backup are accessible through a web interface.

The CQM has all the statistical capability to support 6-sigma and other standards, including yield, PPM, mean, standard deviation, Cp, and Cpk.

Display and control languages include English, Spanish, Italian, German, Chinese, and French, for use in major manufacturing regions.

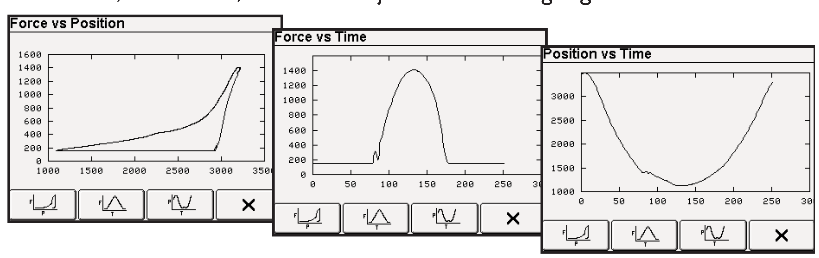



**Figure 4: Detailed display of real time crimp data is readily available to the operator.**

## Crimp Height as a Production Tool

The CQM implements crimp height measurement in a versatile, easy-to-use package that allows wire harness manufacturers to meet contemporary quality standards and improve their production yields.

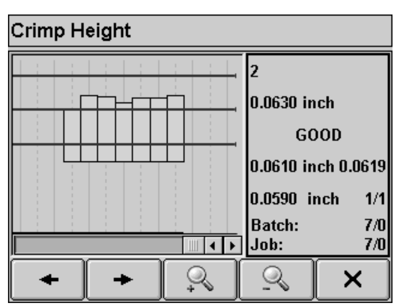



**Figure 5: On-screen bar graphs quickly reveal statistical trends, alerting the operator to impending problems with the process.**



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