FASTENING TECHNOLOGY

FASTENING QUALITY
ASSURANCE PROGRAM

STANLEY®
Assembly Technologies

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**Fastening Quality Assurance Program**

Today’s instrumented electric assembly systems allow the direct measurement of both the dynamic applied torque and the angle of rotation of threaded fasteners during the assembly process.

Dynamic torque is generally considered to have a much more direct relationship to fastener clamp load than static or residual torque, and today most fastener assembly specifications are given in terms of dynamic torque. The ability to measure this dynamic torque during the assembly process and record the peak value for each assembly can provide the assembly plant another level of quality control beyond the traditional method of simply checking residual torque on several samples.

Monitoring the angle of rotation of each fastener can detect various defects or non-normal conditions in an assembly. Cross-threads, poorly tapped holes, damaged threads, etc. can all be detected during the fastening process by setting appropriate limits on the angle of rotation.

The modest investment in instrumented assembly tools and controllers can allow the user to benefit from statistical process control techniques without a large investment in resources engaged in the inspection process. The use of trend analysis techniques can also allow a strategy of assembly error prevention rather than one of detection.

Stanley provides various types of assembly tools for industrial use. Our various customers use a number of different techniques to help assure the overall quality of their fastening process. Below, we give several different methods that can be used to implement a complete fastening assurance program within an assembly plant. Each assembly plant must decide what procedures to use to satisfy the quality requirements for their particular products.

**Levels of Criticality:**

Different fastener joints will have different levels of criticality. Some are directly related to safety or compliance with government regulations, some are related to warranty and customer satisfaction and others may be considered less critical. Typically, users will classify each assembly joint and apply different fastening assurance methods to each type. Ford Motor Co. for example, classifies their fasteners as “Mandatory”, “Significant”, “Warranty” and “Other” and each type has its own surveillance procedure.

**Procedures:**

There are many elements involved beyond the tools themselves. Fasteners, assembled components, tool operators, plant services, and management strategy can all play a role in a comprehensive fastening quality assurance program. A key element in such a program is using a consistent, disciplined approach. It is important to provide clear documentation of procedures and to keep accurate records of any changes to any of the many factors that can affect the results (tools, operators, fasteners, lubricants, fastening strategies, target levels, etc.). This will allow root cause analysis in the event of a problem and also provide a basis for tracking quality improvements.
Assembly Tool Calibration:

The process of calibrating an assembly tool involves comparing the tool’s indicated torque with the actual torque as measured by a master torque measurement system, and then adjusting the calibration value so the tool will indicate the correct torque value. The actual calibration value is affected by the tool’s torque transducer itself, by the gear ratios within the tool, and by the efficiency of the gears. It is the change in gear efficiency throughout the life of the tool that will have the largest effect on the calibration value.

Every Stanley electric tool is calibrated against traceable standards before it is shipped. Tools in the Stanley QPM series also have both the Nominal Calibration Value and the Specific Calibration Value stored in the tool’s memory.

Our Nominal Calibration Values are based on a 95% efficiency factor for all planetary steps and a 94% efficiency factor for most angle heads. These efficiency factors are used along with the actual gear ratio to calculate the nominal calibration value for each model. In addition to this, we allow a production variance of +/- 2% for each gear step. This means that the Specific Calibration Value for a new tool can vary from the nominal value by no more than +/- 2% per gear step, or typically +/- 4% for a double step straight motor, and +/- 6% for a double step angle tool.

For a tool that has been in service, a variation greater than the above values does not necessarily mean the transducer is defective, but more likely the gears are worn a bit and their efficiency factor is different than when new. Often the gears will become more efficient after some use and then, near the end of their life, the efficiency will begin to decrease.

Calibration Joint Simulators:

Proper dynamic torque calibration should be done on a test joint simulator that approximates the torque/angle rate of the production application. Test joints using hardened bolts and spring washer stacks are often used as a durable and economical solution. Care should be taken to avoid excessively “hard” or “soft” test joints as this can often give results that are different than production joints.

Multi-disc pneumatic, hydraulic or electric brakes with adjustable rate controls can also be used, but the torque rate of these devices is usually based on brake pressure vs. time, rather than on torque vs. angle of rotation, as in an actual threaded fastener joint. Any change in tool speed during a tightening cycle on such a joint simulator will result in a change in the torque vs. angle rate for that test joint. As the fastening tool slows down, the joint will become progressively harder and this can affect the results. Also, these brakes can often have inertial properties that are much different than that of a typical fastener and this can affect the performance of the tool. Because of these variables, we recommend spring washer stacks instead of these brakes.
**Tool Calibration Frequency:**

The frequency of tool calibration will depend on the production rates within each assembly plant. We recommend that each tool be calibrated at least once per year, and more often for high production rates, or if there is any indication of a durability issue on a particular application. We also recommend that each tool be re-calibrated following any repair service. Some assembly plants will restart the one-year clock upon servicing an assembly tool, thereby assuring a maximum calibration interval of one year, but those tools that require service within that period will be calibrated more often.

**Automatic Calibration and Diagnostics:**

The Stanley QPM Controllers provide a number of automatic calibration checks during operation. Once the torque calibration value has been determined and stored in the controller’s memory, the controller will automatically adjust the transducer’s output on power up, whenever any parameter is changed, or every 9 minutes of idle use. This internal calibration process is accomplished by first checking and adjusting the zero-offset, and then shunting a precision resistor across the transducer output. This resistor simulates the full-scale output and the controller automatically adjusts the span to match the calibration value. If this full-scale output exceeds internal limits an error E01 warning will be displayed.

The QPM controller also monitors the condition of the torque transducer by continuously measuring the current draw through the transducer circuits. Too low current indicates an open circuit and error E04 will be displayed. Too high current indicates a short circuit and error E05 will be displayed. In addition to this, the controller monitors the digital output of the torque signal. If there is no change in the digital output level for 10 milliseconds, this indicates a saturated signal or a failed A/D converter and error E06 is displayed.

**Angle Calibration:**

The tool’s angle calibration is a function of a digital output from the tool’s resolver, which is used for the brushless motor commutation, and the tool’s total gear ratio. As with the torque calibration value, the angle calibration value is stored in the tool’s memory at the factory. The gear ratio will not change throughout the life of the tool, but it is important to routinely verify that the correct angle calibration value is in place in the controller.

The angle calibration value can be quickly verified by placing the QPS Sigma module into the diagnostics mode, and manually rotating the tool’s output 1 or 10 full revolutions. The number of degrees indicated on the display should agree with the amount of rotation of the tool’s output spindle. Alternatively, since the tool’s indicated RPM is derived from the tool’s internal angle resolver, simply comparing this indicated RPM to that of a master tachometer can also quickly verify the angle calibration.
When an angle control fastening strategy is used, some users require that the indicated angle be compared to that of a master angle encoder. In-line rotary torque transducers are commonly available with built-in angle encoders. Since most angle control strategies require rotating a specified angle beyond a defined torque, a torque/angle monitoring device with this capability should be used as the master device. However, the user should be aware that even when the tool and the in-line torque/angle monitoring device are both programmed to measure angle relative to a snug torque, slight differences in torque calibration at this snug torque can result in large differences in the angular starting point.

**Fastening Process Monitoring**

The Stanley QPM assembly systems allow automatic inspection of the dynamic torque and angle of every fastener. This allows a “Pass/Fail” or “OK/Not OK” decision to be made for each fastener. The population statistics for both torque and angle can also be displayed based on a settable population size.

In addition, these controllers are capable of calculating and displaying complete SPC data based on a settable sample size. This allows the user to track trends in the fastening process that could indicate corrective action is required before defective assemblies are produced.

When a single tool is used on a number of fasteners of different joint rates, the angle of rotation can be very different on each joint and it can be difficult to set realistic angle limits.

**Torque Surveillance**

As with any device, even with all the system checks in place within the QPM fastening system, failure of the torque measurement system can occur and therefore, precautions should be taken to detect and contain any defective products. Such precautions can include several layers of torque surveillance performed at different frequencies.

Since the automatic calibration procedures within the QPM controllers are based on the calibration values that are stored within the controller, these calibration values should be recorded and then verified on a routine schedule. The frequency of this verification can depend on the criticality of the individual assemblies. Some of our customers routinely verify that the correct calibration value is in place at least once per month.

Dynamic torque surveillance is the process of measuring the dynamic torque produced by the tool with an in-line torque transducer and torque-monitoring device. Several samples are taken at some prescribed frequency and the results must agree with the values indicated by the fastening system within a specified limit. This can be done once per day or once per month depending on the criticality of the joint and the ability to contain any defective assemblies since the last check. It can be done on the actual production assembly, if the application allows the master torque transducer to be placed between the tool and the fastener. Or it can be tested on a test joint simulator that has a joint rate similar to that of the production joint.
Residual torque surveillance is the process of measuring the static, breakaway torque on a sample of fasteners. The relationship of this residual torque to the dynamic torque will vary from joint to joint. The relationship of the residual torque to the dynamic torque must be established before residual torque surveillance can be used. In practice, the dynamic torque process capability must first be established for each application by performing a study, usually consisting of 30 samples. This establishes that the process is statistically in control. Along with this dynamic torque study, residual torque readings are taken to establish the residual torque mean and control limits. These limits are then used for residual torque surveillance. The frequency of residual torque surveillance can be once per day or week, but it can also be more frequent if a problem is identified.

Any process surveillance should also include good record keeping. This allows process control charts to be maintained so process trends can be monitored. By taking very small samples at regular intervals, and maintaining control charts, fastening quality can be assured with minimal resources.

**Summary**

The assembly systems offered by Stanley Assembly Technologies can play a critical role in assuring the quality of your products. These systems can not only tighten fasteners to your specifications, but can also perform critical inspection functions as part of the assembly process.

We welcome the opportunity to learn about your specific needs. Our Sales Engineers are available to help you understand how our systems can be integrated into your assembly process to improve the quality of your products.