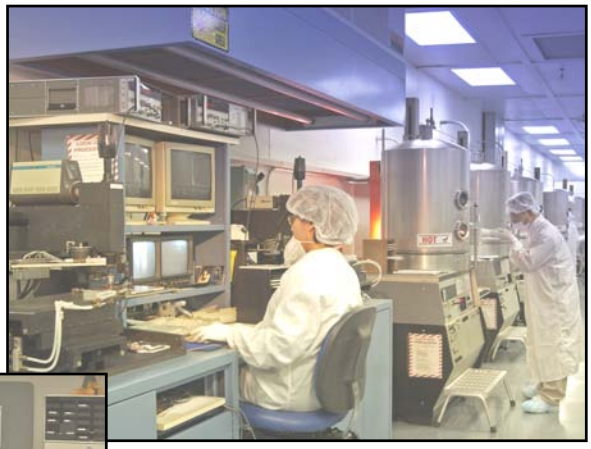
Quality and Reliability Overview



Crystals,
Oscillators,
Sensors

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ISO 9001:2000 CERTIFIED

Quality and Reliability Overview

Introduction

For more than 35 years, Statek Corporation has been a major supplier of ultra-miniature quartz-crystal resonators, oscillators, and sensors. Located in Orange, California, Statek concentrates on supplying highly reliable quartz devices for use in medical, military, and industrial applications. The control over designs, materials, and processes along with an experienced stable workforce allow Statek to consistently provide high-quality devices for the entire lifetimes of our customer's products. Statek's reputation for meeting stringent requirements has earned the company preferred status and continued success with its many customers.

In order to obtain the consistent high quality and reliability demanded by our customers, Statek uses the "process approach" to quality management. In this approach, each operation is modeled as a process, with inputs being transformed into outputs. As exemplified in Figure 1, this allows a clear understanding of Statek's operations.

In this brochure, we briefly describe Statek's quality policy, quality system, product reliability planning, process control planning, product qualification, and lastly product support. For further information on Statek's quality system, the *Statek Quality Manual* is available upon request.

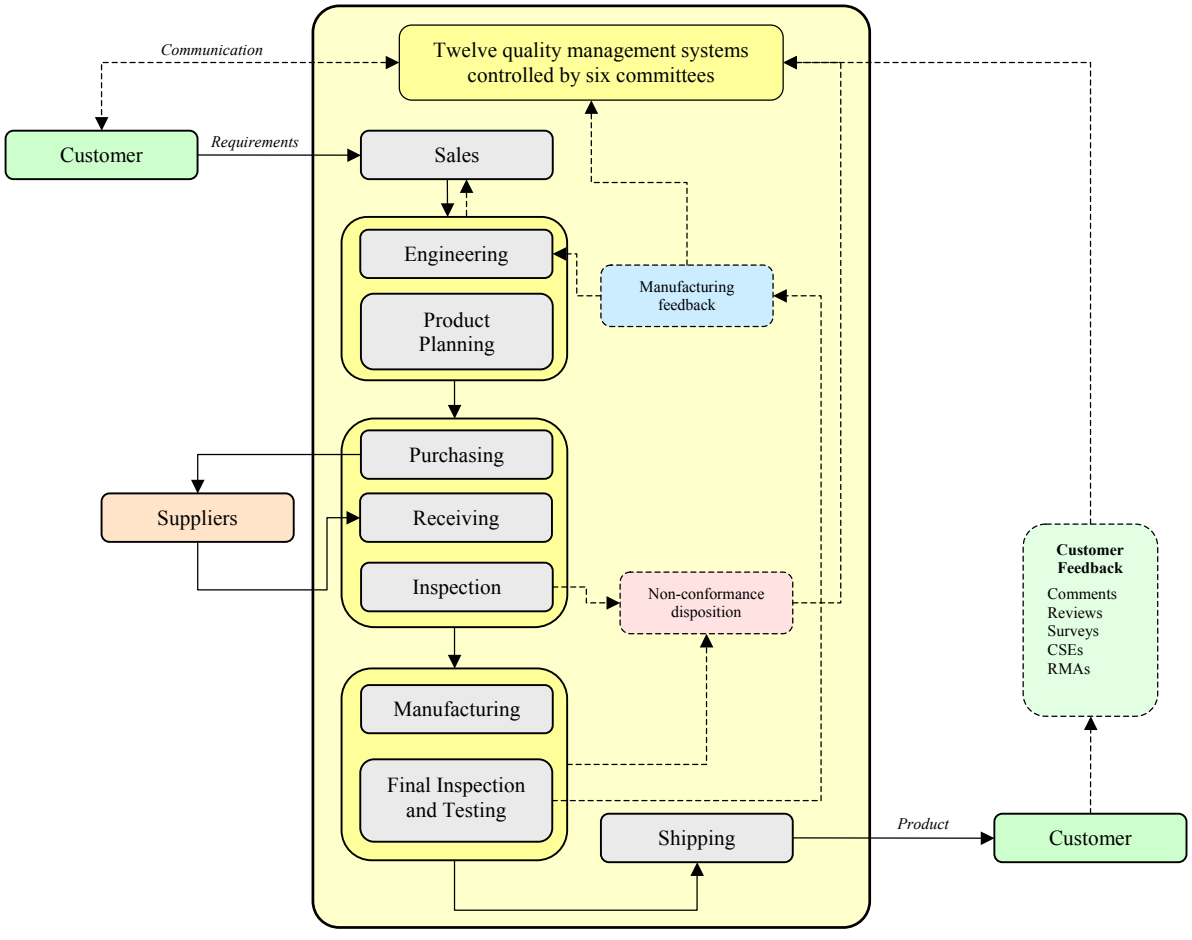

Figure 1—An overview of Statek's quality management process model

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Quality Policy

Statek's quality system begins with its quality policy:

To provide our customers with products and services that meet or exceed their expectations

Quality System

Statek Corporation's quality management system allows us to meet the demands of today's market as well as anticipate and plan for future challenges. It demands continuous improvement with perfection as the constant goal. Statek's quality system is built around ISO 9001:2000 and is certified to this standard.

Product Reliability Planning

Statek's products are designed to meet the quality and reliability requirements of the most demanding applications. To attain this level, Statek follows the design rules developed over its 35 year history as well as the product development requirements of ISO 9001:2000. (Customer and market requirements are defined, design reviews held, designs are verified, and finally designs are validated.)

Statek stress tests its products to ensure their robustness. These tests are chosen to accelerate possible failure mechanisms and thereby verify the reliability of the design. Some examples are shock, vibration, temperature cycling, and high-temperature bakes.

Process Control Planning

To deliver consistent products, Statek plans for the control of its processes and material used in their manufacture.

Process Qualification and Control

When new products are introduced, many times the existing processes are sufficient and so they benefit from the controls already in place. However, when new processes are required, they are planned for, developed, and then controlled. In this way, we are able to deliver a consistent product over the course of many years.

Furthermore, improving and even maintaining quality and reliability over time requires the systematic and continuous reduction of process variations. This is accomplished by using Six Sigma tools to analyze the processes, such as failure mode and effects analysis (FMEA), process mapping, and statistical process control (SPC). When required, more advanced statistical methods are used such as design of experiments (DOE) to provide insight as to how our processes can be improved.

Material Control

An important element in ensuring the consistent quality of Statek's products is the control over the raw materials (e.g., quartz and gold), components (e.g., packages and ICs), and supplies (e.g., photoresist and chemicals) used in their manufacture. Whenever possible, Statek uses domestic suppliers and cultivate long-term relationships to provide stable sources of high-quality materials. Key suppliers are required to supply quality data for each lot and are monitored for quality system maintenance and process control over key manufacturing operations.

Conformance to Statek specifications is regularly checked by incoming quality inspection of key materials. Incoming raw materials and components are tested according to the established criteria per the quality plan. (ANSI/ASQ Z1.4 is used to establish the sampling plan.) Rejected materials are marked as such and returned to suppliers with a Supplier Corrective Action Request.

In order to assure our supply of ceramic packages and lids, Statek's parent company acquired one of our long-time package suppliers. This acquisition ensures that Statek will have priority access to ceramic packages, even in times of general market shortages, as well as giving Statek an advantage for developing custom products.

Statek manufactures all of its quartz crystals starting from quartz bars. To ensure a supply of this raw material, we have a strategic partnership with our domestic supplier and we maintain over a year's worth of safety stock.

Product Qualification

Conformance Testing

Statek performs numerous tests to ensure that its products meet the high-performance and high-reliability needs of its customers. For example, we test electrical performance, package hermeticity, environmental survivability, and mechanical conformity.

For customers with special requirements, we can manufacture and test to MIL-PRF-3098 (for quartz-crystal resonators), MIL-PRF-55310 (for quartz-crystal oscillators), or just about any additional test required by our customers. (An outline of standard tests available can be found at Statek's website.)

When warranted, to ensure product reliability, Statek imposes its own additional tests for such things as hermeticity, particle detection, temperature cycling, solderability, visual, aging, etc.

Product Reliability Testing

Statek has been testing the reliability of its crystals and oscillators by having them stressed (usually high-temperature bakes) for many years. Statek publishes FIT/MTTF data for its crystal and oscillator product families and updates this information yearly in our *Reliability Studies Supplement* available at Statek's website.

Thus far, these tests have yet to identify a failure. Under these conditions we estimate their failure rate (FIT) and mean-time-to-failure (MTTF) as follows.

FIT/MTTF calculation

We begin by modeling our device failure rate λ as being constant in time. From this it follows that the probability R_1 of a given device not failing over a time-interval t (its reliability) is given by

$$R_1(t) = e^{-\lambda t}.$$

If we have n devices tested over a time-interval t, the probability that none of them fail is the product of the probability that each not fail. That is, the reliability R_n of n devices over a time-interval t, is:

$$R_n(t) = \left(R_1(t)\right)^n = \left(e^{-\lambda t}\right)^n = e^{-\lambda nt}.$$

From this it follows that

$$\lambda < \frac{3}{nt},$$

with a confidence greater than 95%. To see this, were $\lambda \geq 3/(nt)$, then the probability of observing no failures would be no greater than e^{-3}, which is slightly less than 5%. Bounds at other levels of confidence are straightforward.

For a constant failure rate, it is straightforward to show that the mean time-to-failure (MTTF) is the reciprocal of the failure rate, i.e.,

$$\text{MTTF} = \frac{1}{\lambda}.$$

So, in our case we estimate that

$$\text{MTTF} > \tfrac{1}{3} nt,$$

with a 95% confidence. Notice that nt is just the number of device-hours of testing, and so, for no failures, the mean time-to-failure is estimated to be greater than one-third the total number of device-hours of testing.

Acceleration factors and reliability

Many reliability studies routinely use a temperature based acceleration factor for evaluating performance of semiconductor devices. While such factors are widely known and generally applicable for silicon devices, the situation is less clear for quartz crystals. Since crystals are electromechanical devices, simple diffusion-based acceleration factors do not adequately represent the complete nature of the device. Therefore, since our reliability studies are performed at elevated temperatures, we understate the reliability of our devices at typical ambient temperatures by not assuming some acceleration factor.

Product Support

Statek's Customer Service Evaluation (CSE) system is designed to assist our customers with the use of Statek's products, e.g., in the design stage or in production. This system enables Statek's engineers to make recommendations on the use of Statek's crystals, e.g., customer board design or manufacturing practices.

Statek's Return Material Authorization (RMA) system is designed to assist our customers in those cases where parts are required to be returned to Statek for evaluation. This system allows us to track the return, drive failure and root cause analyses, assign appropriate corrective action, report back findings, and determine the final disposition of the parts. Statek's failure analysis team serves a critical role in this process.

Lastly, whether you are in the design stage or are in full production, we are eager to help you with the use of Statek's products.

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