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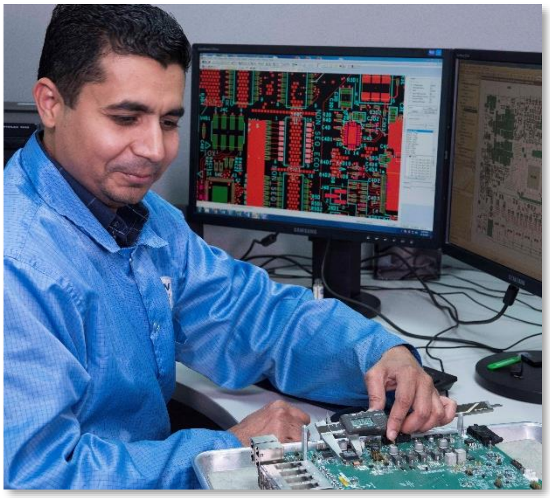

The Quality Equation: Defect Prevention, Data Collection, Inspection and Continuous Improvement

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By Filemon Sagrero

When an original equipment manufacturer (OEM) outsources to an electronics manufacturing services (EMS) company, they aren't simply outsourcing manufacturing, they are outsourcing their reputation. If defects escape the factory, it impacts their brand. There has long been a debate about whether quality assurance (eliminating defect opportunities before they happen) or quality control (inspecting for defects) was the best option for ensuring superior quality. The reality is that given the complexity of many of today's products, both philosophies need to be in play.

The team at SigmaTron International sees four areas that are important in ensuring superior quality:

- Design for excellence (DFX)
- Close monitoring of trends data
- A robust inspection and test strategy
- A focus on continuous improvement.

Design for Excellence (DfX)

DfX is a foundation of a good quality assurance strategy. It involves assessing the product for a range of potential improvements related to manufacturability, testability and product lifecycle management (PLM). It helps eliminate defect opportunities caused by poor design, ensures an optimum test strategy is developed and helps identify any components with availability or obsolescence risk issues. It is best performed during product development.

At SigmaTron, DfX assessments are performed during new product introduction (NPI) when projects don't involve a product development engineering support element during the design phase.

DFM analysis is performed using a combination of Valor and proprietary software tools. The documentation review process also uses a Valor parts library (VPL) to verify the footprint of all components specified in the bill of materials (BOM) against the land patterns used in the layout. This helps eliminate both the opportunity for defects caused by manufacturability issues plus eliminates the non value-added time that can be spent reprogramming machines or re-spinning the printed circuit board layout if the component packaging specified in BOM doesn't match the land patterns used in the layout.

DFM support can be particularly helpful when design constraints drive tradeoffs in packaging technology or layout options due to legacy product footprints, regulatory constraints, operating requirements of the end product or preferred PCB layer count.

In making its DFM recommendations, the engineering team utilizes a five-level, color-coded form that helps prioritize the criticality of each recommendation. The five levels are:

- Red/Critical: a major process/assembly issue
- Orange/Hot: yield improvement suggestion
- Yellow/Warm: minor concern
- Green/Cool: no immediate concern
- Blue/Ignore: no action required.

The color codes apply to both open recommendations and closed recommendations so once an Orange/Hot item is closed, it may be coded as Green/Cool or Blue/Ignore.

Design for testability and overall test strategy are also analyzed. SigmaTron's team has a track record of working with customers to optimize test strategy and test fixtures and equipment.

Close Monitoring of Trends Data

H. James Harrington said, "Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it."

SigmaTron International's proprietary Manufacturing Execution System (MES) system known as Tango, monitors production, quality and warehouse activities. The system provides traceability, is exception-based, has enforced routing capability and integrates with SigmaTron's ERP and iScore systems in real-time.

Tango acts as a partner with production operators tracking each assembly through all processes. On assemblies that require serialization in different formats at different parts of the process, the system ensures that the right serial number is associated with that assembly. Additionally, if any process steps are skipped or if an operator attempts to add the wrong serial number, the system notifies the operator of the error. In short, it provides project status visibility and serves a poka-yoke that prevents errors in manufacturing routing.

It also enhances real-time quality data reporting, enabling the production team to see data by serial number or the entire lot. This helps the team track trends in first pass yield and any repair activities, and quickly identify and correct their root causes.

At an individual facility level, SigmaTron's teams are working to enhance data collection even further. Lean Six Sigma is one of the methodologies used. As an example, its Tijuana, Mexico facility utilizes Lean Six Sigma as one of the primary frameworks for driving continuous improvement. Lean Six Sigma use in the Tijuana, Mexico facility involves Industry 4.0 technology capable SMT lines and secondary assembly operations. The facility utilizes inline 3D solder paste inspection (SPI) and 3D automated optical inspection (AOI) incorporating Industry 4.0 capabilities in its SMT lines and 3D AOI in secondary assembly. Industry 4.0 automated inspection technology opens the door to enhanced levels of process control in the SMT area by creating a closed loop system where inspection stations automatically adjust process parameters on the line based on the trends data they receive. In secondary assembly, the data helps ensure issues in more manual processes are quickly detected and corrected.

To fully utilize the new equipment capabilities, the team developed an accurate program validation database and a methodology for utilizing trends tracking in continuous improvement activities. In addition to the programming done as part of implementation, the machines continue to learn as they analyze trends.

A Robust Inspection and Test Strategy

In a world where keeping product cost low is seen as integral to maintaining competitiveness, it can be difficult to justify the cost of test. After all, if there is a superior quality manufacturing process with appropriate inspection steps and control limits, why is testing necessary? The reality is that even in a production line with automated inspection and perfect process control, there will be some component fallout.

There are multiple reasons:

- Handling at some part in the component's life may have made it vulnerable
- Thermal cycling during production can also cause component fallout
- Product design choices in board level interconnection or higher level assembly operations may overstress solder joints during the assembly process
- Component availability issues may be introducing a higher number of vulnerable components into the manufacturing process.

In short, there are several issues that can lead to non-working product even in highly controlled processes. Test helps keeps these failures from escaping to the field.

While SigmaTron's use of 3D SPI and 3D AOI in most of its operations helps catch most workmanship issues, it won't catch shorts and opens, defective parts or parts that fail due to the rigors of the manufacturing process.

Maintaining acceptable quality levels requires diagnostic testing. When a PCBA does not have accessibility to provide good ICT coverage, a combination of flying probe, functional testing and burn-in/accelerated life testing may be the solution. However, complex functional test can easily have a $100,000 development cost, far outstripping the cost of an ICT fixture. In addition to the actual cost, burn-in and accelerated life tests can add days to production cycle time, increasing work-in-process while decreasing schedule flexibility. When a PCBA is designed to provide good ICT coverage, the subsequent diagnostic test development is less complex. That typically translates to lower development costs and less time per unit in functional tests. It also eliminates the need for subsequent component mortality screening. Plus, while functional test can identify a failure, it often isn't precise in terms of identifying the root cause of the failure which adds to technician debug time. With good coverage, an ICT is much more precise in identifying the defect location. All that said, smaller PCBA footprints do not always support accessibility.

SigmaTron's test engineering teams work with customers to determine the optimum inspection and test strategy either in product development or during NPI.

A Focus on Continuous Improvement

Shigeo Shingo said, "The most dangerous kind of waste is the waste we do not recognize."

While methodology for measuring key metrics is the foundation of any continuous improvement effort, measurement is the just the first step. Employees need the training and tools to facilitate continuous improvement activities. Lean Six Sigma is one of the tools used for this.

In SigmaTron's Tijuana, Mexico facility the Gemba Walk is an integral part of continuous improvement. The term, Gemba, comes from the Japanese word for "the real place." Taichi Ohno, a Toyota engineer and leader, is often credited with developing the concept of the Gemba Walk or the idea that leaders should regularly and frequently be present to observe the work of their organization when and where it takes place.

In a Gemba Walk, leaders visit the work area to glean first-hand knowledge regarding:

- How products are built
- How services are provided
- Current challenges
- Opportunities for improvement.

One of the benefits of Gemba is its role in identifying opportunities for improvement, enabling corrections of any potential issue before they represent a risk for the product. This interaction also enables leaders to learn more about each operator's experiences and knowledge over the process. Gemba and a 5S work environment are fundamental in sustaining any Lean Six Sigma project.

At SigmaTron, weekly Gemba Walks involve a multidisciplinary group. Findings and opportunities are posted on a central Key Performance Indicator (KPI) board and changes in trends drive further analysis. For example, a Gemba walk identified the potential for improvement in a program experiencing significant volume increases.

The Green Belt teams use a DMAIC (Define, Measure, Analyze, Improve, Control) methodology to identify each improvement opportunity and strategize the appropriate solution. They are mentored in their continuous improvement projects by their facility's Yellow Belts.

In the Define phase teams develop a problem statement, identify critical to quality (CTQ) and defect metrics, create project objectives, determine the business case and financial impact of the desired improvement, assess customer impact, set milestones and a timeline, define the project scope and boundaries, and assign team responsibilities. In the Measure phase, the teams measure the variances they associate with the problem they have identified, utilizing core tools such as cause and effect diagrams and Gage R&R measurements. In the Analyze phase, the teams analyze the data they have collected to determine trends and possible corrective actions. In the Improve phase, the teams implement improvements and then utilize design of experiments (DoEs) to determine if the proposed solutions are correcting problem. In the Control phase, measures to ensure continued achievement of desired metrics are implemented.

Ensuring quality in outsourced electronics manufacturing requires a multi-pronged approach that optimizes product for manufacturing and test; tracks quality trends in real-time; educates team members in improvement analysis and problem-solving techniques; and exploits automation to minimize the variation and handling damage that can occur with manual processing. Evaluating an EMS provider's ability to implement this type of approach as part of the selection process helps ensure quality goals are met. Engaging with an EMS provider in the product development process reduces the cost of optimizing the product for manufacturability/testability and may also reduce the cost of test.

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