A Path to Shipping *Zero Defect Parts*

by:
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I was asked by the editors of *Fastener Technology International* magazine, the organizers of the *IFFI* Trade Show Conferences, to provide a program that would identify essentially all of the current quality concerns of fastener manufacturers and to then suggest solutions to address these concerns. In a weak moment, I accepted their request to put together such an all-encompassing program. But once I started working on this program, I felt overwhelmed and unsure that I could actually get my arms around such a broad topic.

Rather than assuming I actually know the major concerns of fastener manufacturers, I called several key management people in some of the leading fastener manufacturers in the fastener industry. I heard several recurring topics and after assimilating all of the input, I concentrated on one pressing topic expressed by all of parties with whom I spoke.

That one pressing quality issue concerning most major fastener suppliers is the growing customer demand for zero defect parts. Recently, several of the automotive plants have adopted, or soon plan to adopt, a new defective parts policy. If one non-conforming part is found, they send all of the remaining parts in that lot to an outside sorting source who will sort 100 % of the parts, return them to the automotive plant, and submit the sorting bill to the supplier.

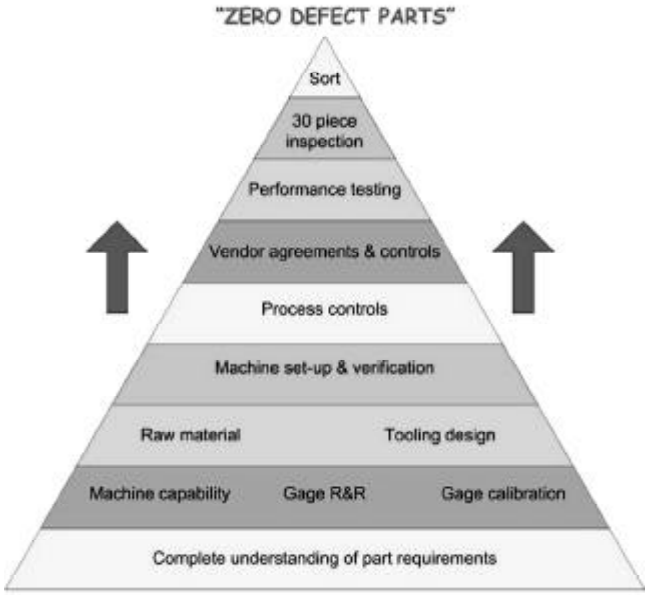
Based on recent issues addressed with its automotive customers, one major supplier estimated that this policy, if instituted, could cost an estimated US$70,000 per month. It is reasonable to believe that as has happened in the past, once this automotive initiative becomes widely known, many other industries will adopt this policy with their fastener suppliers.

People who have been in the fastener industry for very long know that for at least the past 15 years customer satisfaction has been a moving target. Once fastener suppliers figure out how to meet a customer demand for higher levels of service, quality, and performance, the customer hardly takes a breath before imposing a new demand. Fastener suppliers do many things, like regularly using SPC in manufacturing, that were scoffed at just 15 years ago. Suppliers said, "Making fasteners is different from other things. You cannot use SPC in fastener manufacturing." Many suppliers who didn't meet the customer demand for implementation of SPC in fastener manufacturing don't even exist today as fastener suppliers.

Customer demand for zero defect parts will not go away. Many suppliers will figure this out, but several others won't. I predict those who don't figure out how to ship zero defect parts in the near future will be the **Southern Screw**, **Lamson & Sessions**, and **National Lock** companies of the future.

My Path for Shipping Zero Defect Parts

The logical path that I assembled for shipping zero defect parts follows. I do not contend that this is a perfect plan, and it is certainly not an inexpensive plan, but I believe it is a logical plan worth evaluating. This plan can help fastener suppliers determine how they will start shipping zero defect parts in the near future. I decided to express this logical path as though we are building a pyramid (see the illustration below). We must start at the bottom with the most basic elements, and once one level is completed we can proceed to the next. If we continue to build in this logical sequence, we will eventually achieve the pinnacle, which in this project is to successfully ship zero defect parts on a regular basis.



The logical path to shipping zero defect parts.

Level 1. Complete Understanding of Part Requirements

The chances of shipping zero defect parts are pretty slim if the supplier doesn't clearly understand each requirement expressed on the customer's print or specification. And this understanding should occur before production begins. This may sound obvious, but it's really not. I get many calls from suppliers regarding a customer complaint about a part already in production. The supplier wants me to suggest how it can determine conformance to something stated on the part print.

The supplier and the customer should establish a clear understanding as to what the "Mission Critical" part characteristics are before production begins. I think it is safe to say that not every characteristic and requirement on a print will cause a production problem that could require sorting. The same degree of attention may not be necessary for all part requirements. The supplier should know this at the outset.

Simply stated, a supplier should not start making a part until it is completely clear about what the customer wants and precisely how the customer is going to determine product conformance for each requirement. Assumptions about what the customer wants may lead to very expensive consequences if, after shipments begin, these assumptions are proven wrong.

Level 2. Machine Capability, Gage R&R and Gage Calibration

Machine capability, gage repeatability and reproducibility (GR&R) and gage calibration create the foundation for the path to shipping zero defect parts.

Machine Capability—The machines used to process a part must be statistically evaluated to determine they are capable of making the part consistently. The appropriate statistical evaluation is the analysis of Cp. I will not go into the calculation of Cp, but I will say that if a supplier wants to make zero defect parts, its Cp goal should be 2.00 or greater. When the machine's Cp equals 2.00, it is statistically predicted that not more than 3.4 parts in one million produced will be out of the tolerance range used in the part's Cp calculation. A Cp of 2.00 may not always be possible to, but should be the initial goal.

Gage R&R—To monitor a process consistently, an indicating type gage having a goal GR&R of 10% should be used. The closer the GR&R is to 10%, the greater the confidence the manufacturer can have in the gages' process values.

Gage Calibration—Stringent gage calibration procedures must be adhered to in order to assure that a process yields conforming output. A manufacturer can make every required measurement on the precise frequency required, but produce 100% non-conforming parts if the gages measuring the process are not properly calibrated to yield accurate results.

All gages should be calibrated using masters certified by an *ISO 17025* calibration lab accredited by a reputable organization such as the **American Association for Laboratory Accreditation (A2LA)**. This ensures accurate traceability to the **National Institute of Standards and Technology (NIST)**. All calibration procedures should be adopted from national or international standards, and the calibration frequency should be performed on a regular basis to assure the gages maintain accuracy at all times.

Level 3. Raw Material and Gage Design

Raw Material—A fastener manufacturer cannot expect to produce consistent parts with inconsistent raw material. Great care should be taken to thoroughly describe the raw material in every respect including chemistry, tensile strength, grain size and shape, diameter, roundness, coating, etc. The largest coil sizes that are practical should be used to minimize production interruptions.

The raw material for each job should come from only one material supplier and preferably only one mill. Material sources should be limited to those having some form of registered quality plan such as *ISO 9000*, *QS 9000*, etc. Suppliers who do not have a registered quality plan in place may be excellent suppliers, but when the supplier's quality program has gone through the rigors associated with official registration, the purchaser has some assurance that the supplier has a quality system including detailed procedures.

Tool Design—A fastener maker cannot expect to produce consistent parts with poorly designed or inconsistent tooling. The longevity of fastener tooling has a significant effect on the consistency of the products made from that tooling. Computer modeling software for the analysis of manufacturing tooling, such as the DEFORM™ product from **Scientific Forming Technologies Corporation**, Columbus, OH, USA, is now available. The tooling design for all parts requiring zero defects should be analyzed using computer modeling to minimize all stress concentrations in the tooling design, to maximize tooling life and to facilitate consistent part forming.

Great care should be taken in the material selection for all tooling and all tooling should be carbide where practical. There are several grades of carbide. The optimum grade should be specified for each individual tool. Where it is not practical to use carbide, tool steel with a titanium coat should be used. As with carbide, there are many different types of tool steels to choose from. The optimum tool steel grade should be selected for each individual tool. Attention should be given to the investigation of tool steels made using powdered metal technology and those tool steels containing some cobalt.

Each tooling component should be bought from only one source. This will help provide consistency over time. Particularly in the area of tooling, the quality and consistency is much more important to achieving zero defect parts than the tooling cost per piece. Preference should be given to tooling companies that have officially registered quality systems.

Level 4. Machine Set Up Verification

It is obvious that zero defect parts will not be produced if the machines that produce them are not properly set up before production begins. I believe that the operator should be responsible for his or her own quality, but I also believe that two sets of eyes on the same product is far better than one.

It is very common for someone working intensely on a project to make one simple error and despite looking over his or her work many times in the process, could unconsciously make the same mistake repeatedly. For this reason I believe that any job requiring zero defect parts should not be turned on for production without someone (other than the person who set up the job) to look at it and record the fact that it has been reviewed by a second party. This is not an issue of trusting the operator, it is simply an acknowledgment of a human tendency that is not easily eliminated.

Level 5. Process Controls

There are two different aspects to process controls and I feel both have to be used if a fastener maker is to ship zero defect parts. These two process controls are machine monitors and statistical analysis of the ongoing process.

Machine monitors—Machine monitors are not a new concept. They have been available to fastener producers for at least the past 15 to 20 years in one form or another. Process monitors generally measure the energy generated in one way or another during the processing of a part going through that machine. While the process is running properly, the monitor determines what a reasonable energy generation or consumption is. When the energy generation or consumption exceeds the determined normal range, the monitor either notifies the operator or stops the processing equipment.

Excessive energy generation or consumption in a process is an indicator that the process has encountered some inconsistency that needs to be analyzed. When inconsistent energy generation or consumption occurs in a process, it is generally an indication that inconsistent parts are coming out of the process. Zero defect parts will only come from processes that generate or consume reasonably consistent amounts of energy during operation.

Statistical analysis—The fastener manufacturers who believe they can produce zero defect parts without the extensive use of statistics are deceiving themselves. The bona fide use of statistical process control (SPC) to prevent defects in-process, instead of trying to detect defects after they are produced, is the only way fastener manufacturers have a hope of shipping zero defect parts.

Many books are available on SPC. I won't go into detail about SPC, but I will list a few things I believe are essentials in having and using a bona fide SPC system in making fasteners:

- Those part characteristics that "free flow" are those that should be monitored regardless of their impact on the final use of the fastener.

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- Digital indicating gages must be used to monitor processes. The target GR&R for each measurement should be 10% or as close to that as possible with available technology.
- The digital gages must be connected to some form of computerized data collection system that provides the operator with immediate, easy-to-understand information about the process. Generally, this is going to involve a computer network throughout the entire manufacturing facility.
- Achievement of ±Six Sigma should be the goal. This is an area I strongly suggest all fastener manufacturers learn about. I also suggest that at least one employee become a registered Six Sigma Black Belt through a reputable training organization. If parts are made so consistently that the dispersion of their measured values over time provides ±Six Sigma (standard deviations) within the product's tolerance requirements, those parts should never have over 3.4 defective parts within a continuous production run of 1,000,000 pieces. This is as close to predicting the production of zero defect parts as a manufacturer can expect to get. A goal of ±Six Sigma, a machine Cp of 2.00, and a Cpk of 2.00 must be set for each manufacturing process.

Level 6. Vendor Agreements and Controls

After a fastener manufacturer has done all the things I have suggested above (and often more) to assure zero defect parts, they usually send the parts to outside sources like heat treaters and coaters for final processing. Outside processors frequently contaminate homogeneous, carefully processed parts with foreign parts from other customers. This mixing is not intentional. Mixing is just a reality in the bulk handling of manufactured parts unless great care is taken to avoid it.

Fastener makers who must ship zero defect parts must take the time and effort to meet with their outside processors to stress the importance of not mixing in foreign parts. The manufacturer and the outside processor must reach specific agreements on how parts will be handled and processed to avoid the introduction of foreign parts into the lots they process.

Preference should be given to processors that have formally registered quality systems which assure the fastener manufacturer that the processor does have detailed operating procedures. Companies that have gone through the demands of formal registration provide a better chance for consistent, mixing-free part processing than do those that have not. Fastener manufacturers should insist that their processors use SPC in logical ways throughout their operation to assure consistent, mixing-free part processing,

Preference should also be given to processors that can perform both heat treating and coating or other required processing over those sources that only provide a single service. The total part process sequence that involves the participation by the fewest number of organizations is most likely to result in shipping zero defect parts.

Level 7. Performance Testing

Most of the in-house processing by the fastener manufacturer has been to achieve dimensional part conformity. That, plus the effects of the outside or final processes, impacts the part's performance. Perfectly shaped parts are worthless if they do not perform the task for which they were designed and specified.

Parts must be put through all physical and performance tests required by the part print or specification. To ship zero defect parts, the supplier must be assured that the parts perform satisfactorily in all respects. Statistical analysis should be used to evaluate performance characteristics. If inconsistency is detected in part performance, a root cause for the inconsistency should be sought. The inconsistency could be derived from a dimensional issue or a final processing issue.

Level 8. 30 Piece Inspection

Final inspection is theoretically unnecessary if SPC has been used throughout the processing of a continuously processed manufacturing lot. But, many fastener suppliers have expressed a frustration over how to determine which parts should be sorted and on which type of sorting equipment.

My suggestion is to take 30 randomly selected parts from each lot and dimensionally inspect them at least for the customer defined "Mission Critical" dimensions, if not for all of the dimensions. Perform a Cpk analysis on the results. Make sorting decisions based on the Cpk values on the various characteristics. Keep in mind that a Cpk of 1.00 predicts approximately 3000 defective parts per million are in the lot and a Cpk of 2.00 predicts not over 3.4 parts per million in the lot.

Level 9. Sorting

I suggest all lots that must be zero defect, be roller sorted before packaging. It is thought that about 80% of all nonconforming parts are due to the presence of foreign material and not incorrectly manufactured parts. Roller sorting is the cheapest, fastest method available and is very effective, but not perfect, in removing foreign parts from manufacturing lots.

The fastener industry now has several types of sophisticated sorting equipment available. Some of the technologies employed now in sorting are high-speed vision, laser, sonic and eddy current. No single piece of equipment is best for all types of part characteristic discrimination. This equipment is expensive—commonly ranging in price from US$20,000 to US$250,000 per unit. Few, if any, fastener manufacturers can afford to own enough units to send 100% of their parts through one of these types of equipment.

Using the Cpk analysis described in Level 8, the fastener manufacturer can empirically determine which part characteristics to sort for. Then the best suited piece of sophisticated sorting equipment can be chosen for a specific lot of parts. If it is determined that one of the more sophisticated methods of sorting is required, the roller sorting suggested above does not necessarily need to be done.

Those fastener manufacturers waiting for customers to lower their quality demands are just marking time until they have no more customers to worry about satisfying. More and more customers are demanding zero defect parts. Shipping zero defect parts requires a great deal of understanding, planning, analysis and flawless process execution. I hope this article provides fastener manufacturers with a few ideas and possibly a logical path by which they can successfully and consistently ship zero defect parts.

To learn more, contact the author or **Circle 220.** FTI

Greenslade & Company, Inc. *is an ISO 17025 accredited provider of dimensional calibration services to suppliers of mechanical fasteners in the USA. The company offers the "Three Guarantee Calibration Program" that guarantees five day or less turnaround, error-free certificates and the meeting or beating of all published calibration prices within the scope of Greenslade's accreditation. The firm also supplies a range of fastener inspection equipment.*

Joe Greenslade *is a regular contributor of articles to this magazine. Greenslade has been active in the fastener industry since 1970 and has held positions with major fastener producing firms.*