How to establish in the bus industry QMS statistical process control according to IATF 16949

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Abstract. In this paper we’ll explain how in the bus industry according to IATF 16949 we determined the appropriate use of statistical tools, and Statistical Process Control (SPC) is the usual choice. SPC is a methodology mainly used to monitor and control the behavior of the manufacturing process. The main purpose of SPC is to prevent that the non-conform products go out from the production workshop to be delivered to the final clients. Statistical Process Control, part of IATF 16949 core tools, that is an analytical decision-making tool will allow to the plant from the bus industry to determine whether the process is performing correctly or not and one main point we’ll be to reduce wastes. The main advantage over the other methods used in quality control (e.g. inspection), SPC has the advantage of detecting problems before they have occurred. We’ll use the most successful and widely used SPC tools: control charts to identify the wastes.

1. Introduction

In clause 9.1.1.1, IATF 16949 [1] requires organizations to determine the appropriate use of statistical tools, and Statistical Process Control (SPC) is the usual choice. SPC is a methodology mainly used to monitor and control the behavior of the manufacturing process, but it can be used for any process that has measurable outputs. Its main purpose of SPC is to prevent that the non-conform products go out from the production workshop to be delivered to the final clients.

In the bus industry we need to implement Statistical Process Control to:
- maintain processes in a state of statistical control
- distinguish between special cause and common cause variation
- use reliable information to decide when or when NOT to take action
- assess process capability
- determine whether process improvements are successful (i.e., before and after)
- use a common language for communicating process control and capability [2]

In the world of ever-increasing competition and raw material prices, organizations must concentrate on their processes in order to increase efficiency and reduce costs. Relying only on the inspection of products after production to detect quality issues is not enough for many companies. The aim of implementing SPC is to move the company from detection after production to prevention. Application of SPC enables an operator to detect trends and any special events in the manufacturing process before they lead to defective product or scrap.
2. Basic Stages of SPC

In this article we made the description of the first 5 steps and the final step (assess process capability) will be present in another paper.

Figure 1. Basic stages of SPC

Figure 1 is inspired from many automotive procedures and is the base of our internal procedure from the bus industry. The first author of this work is a consultant in the automotive industry and in the same a quality manager so we had the opportunity to improve continuously the steps from the statistical process control methodology and we identified that the first pillar is critically to arrive have added value after the interpretation of the control charts and the calculation of the performance and capability indicators.

Step 1 – Identify characteristics or parameters to measure and monitor SPC characteristics, or variables.

The characteristics or parameters used in statistical process control must be:
- independent process variables (i.e., unaffected by other characteristics or operations)
- feasible to measure on the plant floor (i.e., measured the way they are machined).

The main sources for characteristic selection in the bus industry:
- Customer input
- Lessons learned from previous processes or products
- Brainstorming
- Cause and effect diagrams (i.e., fishbone diagrams)
- Process Failure Mode and Effect Analyses (PFMEAs)

Step 2 – Develop sampling plan

The sampling plan major components are described below:
Characteristic(s), or parameter(s), to measure and monitor are identified by a cross-functional control planning team. The same cross-functional team also determines sample size and frequency. A sample size should be large enough to detect risks to customers and small enough to make the best economic sense. As a general rule for sampling variable data, small sample sizes of 4 or 5 consecutive parts are recommended because:
- they are less costly than larger sample sizes.
- they facilitate the use of a Range chart. (A later section will cover Range charts.)
- less chance exists of a change occurring while the sample is being taken.
- they are sufficient to normalize most processes when taking 25 samples (i.e., subgroups) of 5 pieces.

The additional considerations for selecting sample size and frequency that we took into account are described:
- Ease of obtaining samples
- Ease in taking sample measurements
- Cost of samples
- Cost of failing to detect process problems
- Time it takes to sample.
Step 3 – Conduct Measurement System Analyze
Measurement System Analyze is a starting point used to validate the measurement system or measurement process that has to be realized mandatory before to make adjustments, to implement solutions, to plan tests, to perform a complex statistical analysis.

Step 4 – Collect data and measurement
The rates measured while the self-control for the subassemblies and also for the assembled chassis are used to realize the control charts. Operators have computers at their working stations to introduce the rates measured while the self-control and maintain control charts. This gives an information just in time, closest to the operation.

The rates that can’t be measured directly by the operator traditionally are measured while the 3D control realized by the metrology laboratory on the assembled chassis at the end of the production line.

Step 5 – Create control charts
Statistical Process Control (SPC) is a technique that use a visual powerful instrument: control charts to monitor, analyze, predict, control, and improve a production process. Control charts were implemented like a powerful tool for SPC by Shewhart; they are the most useful tools in the analysis of production process variations. We need to anticipate the quality level of the products or services. In the workshop we need stable processes during the time without special events that can create a strong perturbation. The stability means the absence of special causes of variation for the serial processes, after the industrialization phase is finished.

Process control charts are strong visual instruments, very clear, based on connected-point charts. The points are plotted on an x/y axis. The time is normally represented on the x-axis usually. Each point from the control chart is the average of a subgroup (of 5 parts normally) or ranges of variation between subgroups and they can also be individual measurements (I-MR - Individual – Moving Range diagram).

The bottom and up horizontal lines represent the average measurement and control limits are drawn across the chart. The special software from today, like Minitab or Q-DAS identify any points out of control limit directly on the chart.

![Figure 2. Control Chart for a subassembly (Rear Part) for a chassis Euro 6 (The points out of control are identified in red)](image)

Control charts is a preventive tool imposed by SPC Manual of AIAG that is the base of continuous improvement. Control charts are used to survey the processes and to put in evidence how the process is working, and how the process and capabilities are affected by the special causes appeared in the process. This information is used to establish the root cause and to define an action plan to improve the quality.
Control charts are the proofs to indicate if the process is in control or out of control. They can demonstrate quickly and clear the variance of the output of a process over time, such as a measurement of geometry, or temperature. These diagrams are able to put in evidence this variance against upper and lower limits to see if it fits within the expected, specific, predictable, and normal variation levels [5].

To interpret correctly a control chart we need experience in the production process to decide if the process is considered to be in control, and in this case we have a variance between measurements that is a normal random variation that is inherent in the process. In the case that we have a variance that is outside the limits, or has a run of non-normal points, the process is considered to be out of control [5].

There are a handful of control charts that are commonly used. They vary slightly depending on their data, but all have the same general fundamentals: data points plotted on an x/y axis, where x represents time, along with an average or center line and upper and lower control limits [5].

To interpret a control chart we need to analyze more than if the data points recorded on a control chart are between the control limits and there some rules to supply a clearer interpretation. If the process is under the control we are talking only about common causes and no special causes have been identified. There are many out-of-control signals. In this article will present the eight most typical special cause signals. Most SPC software packages apply all these criteria and possibly more. However, it is not necessary to use all available criteria. We need to establish for our processes the criteria that can afford to us to have an equilibrium between the non-quality and the cost of the quality. Each supplementary criterion increases the sensitivity of discovering of a special cause but also increases the chance of a false signal. The objective is to use the minimum criteria necessary to catch all real signals and to avoid false signals. The most common rules used to realize the interpretation of control charts are presented below and they are included in the statistical process software, like Minitab [3,4]:

1. 1 point > 3 standard deviations reported the centerline
2. 2 out of 3 points > 2 standard deviations reported to the center line (same side) [6]
3. 4 out of 5 points > 1 standard deviation reported the centerline (same side) [6]
4. 15 consecutive points within 1 standard deviation reported the centerline (either side)
5. 8 consecutive points > 1 standard deviation reported the centerline (either side)
6. 7 consecutive points on the same side reported to the centerline [7]
7. 6 increasing (decreasing) consecutive points
8. 14 points, alternating up and down, all consecutive [7].

![Figure 3. Example of the tests performed by Minitab to identify the points of control from control charts](image-url)
Diagrams from figure 2 and 3 are made by based on the real data obtained on the rear part of the bus. The results obtained by SPC showed that there is a problem to keep the process under control and to assure repeatability of some functional characteristics. To avoid a 100% control of the pieces we changed the manual welding by a robotic welding with a new specific welding device specific for the robot. Only based on these diagrams we arrived to put in evidence this instability of the manual welding process for the traverse (rear part bus piece), the frequently 3D control wasn’t efficient because the parts were reworked without to put in evidence the problems so the risk was very high without a 100% checking of the part.

Nowadays, Minitab is a very powerful software used in the automotive industry to realize the statistical control of the process and is a base also in the plants that implemented Six Sigma methodology. Beside of Minitab, also Microsoft Excel’s functionalities can be used in the statistical field in production because is easy to use and access but it has more limitations [3,4].

3. Conclusions
This paper is realized based on the real data from the industrial process and showed the importance of the SPC applied on the rear part of the bus. This instrument allows to the supplier to deliver parts without quality problems concerning the functional rates and specially to put in evidence the necessity to change the technology and the type of the welding device before to generate quality problems to the client.

The work is inspired from the real industrial life based on the internal quality problems identified by SPC realized in the working station; the process was not under control. The paper is based on the industrial procedure that are applied to improve the industrial the processes and there is a very preventive and strong instrument with a lot of benefits. Operators can often maintain control charts at their job stations. This gives the people closest to the operation reliable information on when to take action and on when not to take action to maintain a stable, statistically controlled process.

We used control charts to:
- follow process stability over time
- anticipate future process performance
- create a base for support process improvement
- describe process performance
- put in evidence the controlled (i.e., random or common) and uncontrolled sources of variation (i.e., assignable to a special cause).

We obtained in this way an essential information on when to take action and on when not to take action to maintain a stable, statistically controlled process. This has an enormous impact in the reducing of the number of the geometry quality problems reported to the startup of this project when we didn’t implement the control charts in each working station.

In a future paper will treat the seven step: the way of calculation of the capability and performance indicators and how they are interpreted to improve the industrial processes. This calculation can be made only after the process is under the control, this can be proved on the based on the diagram control.

References
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