**Kaunas University of Technology**
Faculty of Mechanical Engineering and Design

# Development of the Wastegate Actuator Assembly Production Process Applying DMAIC Quality Improvement Approach

Master's Final Degree Project

**Aysegul Arslan**
Project author

**Assoc. prof. Jolanta Baskutienė**
Supervisor

**Kaunas, 2024**

**Kaunas University of Technology**
Faculty of Mechanical Engineering and Design

# Development of the Wastegate Actuator Assembly Production Process Applying DMAIC Quality Improvement Approach

Master's Final Degree Project

Industrial Engineering and Management (6211EX018)

**Aysegul Arslan**
Project author

**Assoc. prof. Jolanta Baskutienė**
Supervisor

**Prof. Vytautas Jūrėnas**
Reviewer

**Kaunas, 2024**

**Kaunas University of Technology**

Faculty of Mechanical Engineering and Design

Aysegul Arslan

# Development of the Wastegate Actuator Assembly Production Process Applying DMAIC Quality Improvement Approach

Declaration of Academic Integrity

I confirm the following:

1. I have prepared the final degree project independently and honestly without any violations of the copyrights or other rights of others, following the provisions of the Law on Copyrights and Related Rights of the Republic of Lithuania, the Regulations on the Management and Transfer of Intellectual Property of Kaunas University of Technology (hereinafter – University) and the ethical requirements stipulated by the Code of Academic Ethics of the University;

2. All the data and research results provided in the final degree project are correct and obtained legally; none of the parts of this project are plagiarised from any printed or electronic sources; all the quotations and references provided in the text of the final degree project are indicated in the list of references;

3. I have not paid anyone any monetary funds for the final degree project or the parts thereof unless required by the law;

4. I understand that in the case of any discovery of the fact of dishonesty or violation of any rights of others, the academic penalties will be imposed on me under the procedure applied at the University; I will be expelled from the University and my final degree project can be submitted to the Office of the Ombudsperson for Academic Ethics and Procedures in the examination of a possible violation of academic ethics.

Aysegul Arslan

*Confirmed electronically*

**Kaunas University of Technology**

Faculty of Mechanical Engineering and Design

# Task of the Master's Final Degree Project

**Given to the student** –Aysegul Arslan

1. **Title of the Project**

Development of the Wastegate Actuator Assembly Production Process Applying DMAIC Quality Improvement Approach

*(In English)*

Atidarymo vožtuvo pavaros mazgo gamybos tobulinimas taikant kokybės gerinimo metodiką DMAIC

*(In Lithuanian)*

2. **Aim and Tasks of the Project**

Aim: to propose a solution for the wastegate actuator assembly production process improvement and scrap rate reduction by applying the DMAIC quality improvement approach

Tasks:

1. to analyze the production process of the wastegate actuator assembly at company ‘X’;
2. to perform statistical scrap rate analysis of the wastegate actuator assembly process;
3. to propose scrap rate reduction solutions applying the DMAIC approach for the number-one scrap cause identified by the statistical analysis;
4. to evaluate the possible financial gain of the proposed solution.

3. **Main Requirements and Conditions**

ITAC software is recommended for the production process data collection, Minitab software is recommended for the statistical analysis, QS-STAT, SOLARA software is recommended for preparation of the capability and measurement system analysis(MSA) report.

4. **Additional Requirements for the Project, Report and its Annexes**

Not applicable

| | | | |
|---|---|---|---|
| Project author | Aysegul Arslan | | 02-10-2023 |
| | *(Name, Surname)* | *(Signature)* | *(Date)* |
| Supervisor | Jolanta Baskutienė | | 02-10-2023 |
| | *(Name, Surname)* | *(Signature)* | *(Date)* |
| Head of study field programs | Regita Bendikienė | | 02-10-2023 |
| | *(Name, Surname)* | *(Signature)* | *(Date)* |

Arslan Aysegul. Development of the Wastegate Actuator Assembly Production Process Applying DMAIC Quality Improvement Approach. Master's Final Degree Project, supervisor assoc. prof. Jolanta Baskutienė; Faculty of Mechanical Engineering and Design, Kaunas University of Technology.

Study field and area (study field group): Production and Manufacturing Engineering (E10), Engineering Sciences (E).

Keywords: Wastegate actuator assembly; DMAIC; quality control; statistical analysis; process capability.

Kaunas, 2024. 64 p.

**Summary**

In order to maintain its profitability in a business environment that is becoming more competitive day by day, the automotive industry has made it its primary goal to increase the efficiency of automatic production lines, which have become the industry standard, and to reduce the amount of scrap and line downtime, while remaining within the quality limits demanded by the customer. Companies are always very anxious to examine the improvement potential of each station and each process step in the production lines and carry out development studies on areas where the potential is seen. This particular study provides practical applications of the process improvement of the wastegate actuator assembly process following the DMAIC approach. During the flow of the DMAIC circle, several different tools were used Pareto chart, control chart, Process Feasibility Analysis, and Design of Experiment which allowed to define the problems, measure the effects of actual aspects, analyze in a wider perspective to understand the potential solutions, to improve the focused process by applying the solution option properly, and finally to control the improved process to understand if the solution create an effect to key points. Suppression PCB failure was selected as a focus point of the study since it was stated as the most popular failure during the control period of the assembly process. DMAIC methodology was applied to reach the target improved key values, and based on the results, the pressing tool was updated to decrease the suppression PCB failure by increasing the adaptiveness of the tool to serve in optimum quality in the requested tolerance range by the customer. A new data set was provided by the assembly line of Company “X” after updated tool implementation, and it was proved the effective process improvement implementation at the assembly line of the wastegate actuator was established. Finally, the targeted values were achieved as a result of the implementation study.

Arslan Aysegul. Atidarymo vožtuvo pavaros mazgo gamybos tobulinimas taikant kokybės gerinimo metodiką DMAIC. Magistro baigiamasis projektas, vadovė doc. Jolanta Baskutienė; Kauno technologijos universitetas, Mechanikos inžinerijos ir dizaino fakultetas.

Studijų kryptis ir sritis (studijų krypčių grupė): Gamybos inžinerija (E10), Inžinerijos mokslai (E).

Reikšminiai žodžiai: Išmetimo vožtuvo pavaros mazgas; DMAIC; kokybės kontrolė; Statistinė analizė; proceso galimybė.

Kaunas, 2024. 64 p.

## Santrauka

Siekdama išlaikyti pelningumą kasdien vis konkurencingesnėje verslo aplinkoje, automobilių pramonė iškėlė savo pagrindinį tikslą padidinti pramonės standartu tapusių automatinių gamybos linijų efektyvumą ir sumažinti gamybos apimtis. laužo ir linijų prastovos, neviršijant kliento reikalaujamų kokybės ribų. Įmonės visada labai nori ištirti kiekvienos stoties ir kiekvieno proceso etapo gamybos linijose tobulinimo galimybes ir atlikti plėtros tyrimus srityse, kuriose matomas potencialas. Šiame konkrečiame tyrime pateikiami praktiniai atliekos vožtuvo pavaros surinkimo proceso tobulinimo taikymai pagal DMAIC metodą. DMAIC rato eigos metu buvo naudojami keli skirtingi įrankiai Pareto diagrama, valdymo diagrama, proceso galimybių analizė ir eksperimento planavimas, kurie leido apibrėžti problemas, išmatuoti faktinių aspektų poveikį, analizuoti platesne perspektyva, kad suprastų potencialą. sprendimus, pagerinti sutelktą procesą tinkamai taikant sprendimo variantą ir galiausiai kontroliuoti patobulintą procesą, kad suprastumėte, ar sprendimas sukuria poveikį svarbiausiems dalykams. Slopinimo PCB gedimas buvo pasirinktas kaip tyrimo fokusavimo taškas, nes jis buvo nurodytas kaip populiariausias gedimas surinkimo proceso kontrolės laikotarpiu. Norint pasiekti tikslines patobulintas pagrindines vertes, buvo pritaikyta DMAIC metodika, o remiantis rezultatais, presavimo įrankis buvo atnaujintas, siekiant sumažinti slopinimo PCB gedimą, padidinant įrankio prisitaikymą prie optimalios kokybės aptarnavimo kliento pageidaujamame tolerancijos diapazone. Įmonės „X“ surinkimo linija po atnaujinto įrankio įdiegimo pateikė naują duomenų rinkinį ir įrodė, kad buvo nustatytas efektyvus proceso tobulinimo įgyvendinimas ištekėjimo vožtuvo pavaros surinkimo linijoje. Galiausiai, atlikus įgyvendinimo tyrimą, numatytos vertės buvo pasiektos.

## Table of Contents

## List of Figures

## List of Tables

## List of Abbreviations and Terms

**Abbreviations:**

WGA – Wastegate Actuator;
DMAIC – Define, Measure, Analyze, Improve, and Control;
PCB – Printed Circuit Board;
FPY – First Pass Yield;
AMS – Automated Mounting System;
AOI – Automated Optical Inspection;
EOL – End of Line;
CW – Calendar Week;
SPC – Statistical Process Control;
SIPOC – Supplier, Input, Process, Output, Customer;
MSA – Measurement System Analysis;
DOE – Design of Experiment;
VOC – Voice of Customer;

# Introduction

The search for quality and efficiency in assembly processes is a never-ending project in the dynamic world of car manufacturing. The goal of this master's thesis is to improve the assembly process of wastewater actuators in the automotive industry. The main focus is on mitigating excessive scrap rates, which go beyond simple statistics to have a substantial effect on overall operating efficiency and final product quality. The critical need for improvements in the assembly of Wastegate Actuators, which are essential parts that regulate turbocharger valves, highlights the significance of this research. The accuracy and dependability of their assembly have a significant impact on the efficiency and power output of engines as these components directly affect boost pressure and engine torque. Using the DMAIC (Define, Measure, Analyze, Improve, and Control) strategy a Six Sigma technique is the project's unique approach. This method, which is well acknowledged for its effectiveness, is the foundation of a statistically based quality control system that provides a methodical framework for breaking down and addressing complicated problems. The issue at hand is a high rate of scrap in the WGA assembly process that prevents first-pass yield FPY goals from being achieved. One major bottleneck that was harming the assembly line's overall performance was the suppression of PCB pressing failures. The main goal is to use DMAIC to approach this challenge methodically, guaranteeing a thorough grasp of the issue and putting focused solutions into practice for long-lasting gains. Beyond only theoretical understanding, this research is expected to have practical applications. The study seeks to lower scrap rates, boost assembly line productivity, and provide useful suggestions for comparable problems in assembly production by effectively resolving the suppressed PCB pressing failure. The results of this study have the potential to significantly impact the automotive sector's continuous pursuit of enhancing quality, optimizing operational effectiveness, and maintaining economic viability. A thorough examination of the DMAIC approach and how it is used to address the unique problems with the WGA assembly process is provided in the next chapters. This thesis aims to provide significant insights and concrete solutions that can drive improvements in process optimization and quality control in the automotive industry via a systematic examination.

Aim: to propose a solution for the wastegate actuator assembly production process improvement and scrap rate reduction by applying the DMAIC quality improvement approach.

To reach the aim the following must be solved:

1. to analyze the production process of the wastegate actuator assembly at company ‘X’;
2. to perform statistical scrap rate analysis of the wastegate actuator assembly process;
3. to propose scrap rate reduction solutions applying the DMAIC approach for the number-one scrap cause identified by the statistical analysis;
4. to evaluate the possible financial gain of the proposed solution.

Hypothesis: Implementing the DMAIC quality improvement approach can reduce the scrap rate in the wastegate actuator assembly production.

## 1. Overview of The DMAIC Approach at the Automotive Production Process

The automobile industry faces a challenging economic environment that threatens its long-standing status as a successful sector that consistently experiences year-over-year sales increases. The upward trend of automobile sales volume, which had been rising consistently since 2015 but declined in 2018, is noticeably deviated from, according to data from Statista. The Covid-19 epidemic has made matters worse [1]. Besides this, failures are widely disapproved of in the automobile business because of the substantial negative effects on reputation and the economy. As such, suppliers need to set up their own procedures for evaluating component failures and taking proactive measures to fix them before they affect the end user. A range of quality-related approaches are utilized in order to determine the root causes of problems. One of the pillars of the automobile industry is the control of quality. From the ideation of the product to its delivery to the final consumer, every stage is meticulously prepared to avoid any possible setbacks. To guarantee quality in product creation, a thorough grasp of material qualities and production procedures is necessary. However, new issues requiring effective solutions are brought about by the interaction of material attributes with production processes. As an outcome, effective management of scrap data is crucial for understanding the root causes of production problems and figuring out when to take remedial action. By reducing scrap costs and optimizing operations, this strategy seeks to promote a continuous improvement culture. In other words, the industry is forced to adopt concepts such as lean methodologies in addition to techniques that reduce production costs and improve the effectiveness of production systems by getting rid of inefficient procedures [2]. Often, the DMAIC technique is used to achieve the goals specified in a strategic plan for a company. DMAIC is a data-driven cycle of improvement that is applied to improve, optimize, and stabilize business designs and processes. Six Sigma programs are mostly driven by this organized framework, which emphasizes the discovery of underlying causes based on real data. Analysis of the major issues facing the automotive sector that have a significant impact on final quality, such as problem-solving, customer-specific requirements, quality management systems, product development, inexperience, supplier management, change management, core tools, warranties, and metrics, has identified key areas that need to be addressed. These include joint initiatives to start changes, deliberate hiring and information sharing, the application of uniform standards, initiatives to encourage organizational openness, and meticulous data analysis to identify the underlying causes of issues. This all-encompassing strategy aims to improve and address organizational quality [3].

### 1.1. DMAIC Approach

In the manufacturing and process sectors, Six Sigma is an all-encompassing organizational strategy that aims to achieve zero faults and minimize variances. Organizations are prompted by this program to review their procedures, get rid of bottlenecks, and continuously provide excellent results. By regularly reviewing and improving current business processes, the Six Sigma technique contributes to increased operational effectiveness. Practitioners of Six Sigma techniques are skilled in assessing corporate processes to pinpoint areas that may be improved. Six Sigma is used to reduce variance, improve process performance, and guarantee a constant level of quality in the final product. As a result, this methodology yields lower failure rates, more profitability, higher product quality, and higher customer satisfaction [4].

The DMAIC methodology is a well-established and rigorously tested approach for enhancing processes, commonly employed within the framework of Six Sigma initiatives. The abbreviation

DMAIC stands for five interrelated phases: define, measure, analyze, improve, and control. Each phase's simplified definitions in Figure 1 are as follows:

- Define by locating, ranking, and selecting the relevant project,
- Measure the performance, parameter scope, and critical process features.
- Conduct an analysis by determining key causes and process factors,
- Enhance by altering the procedure and raising performance,
- Maintain control by keeping the gain.

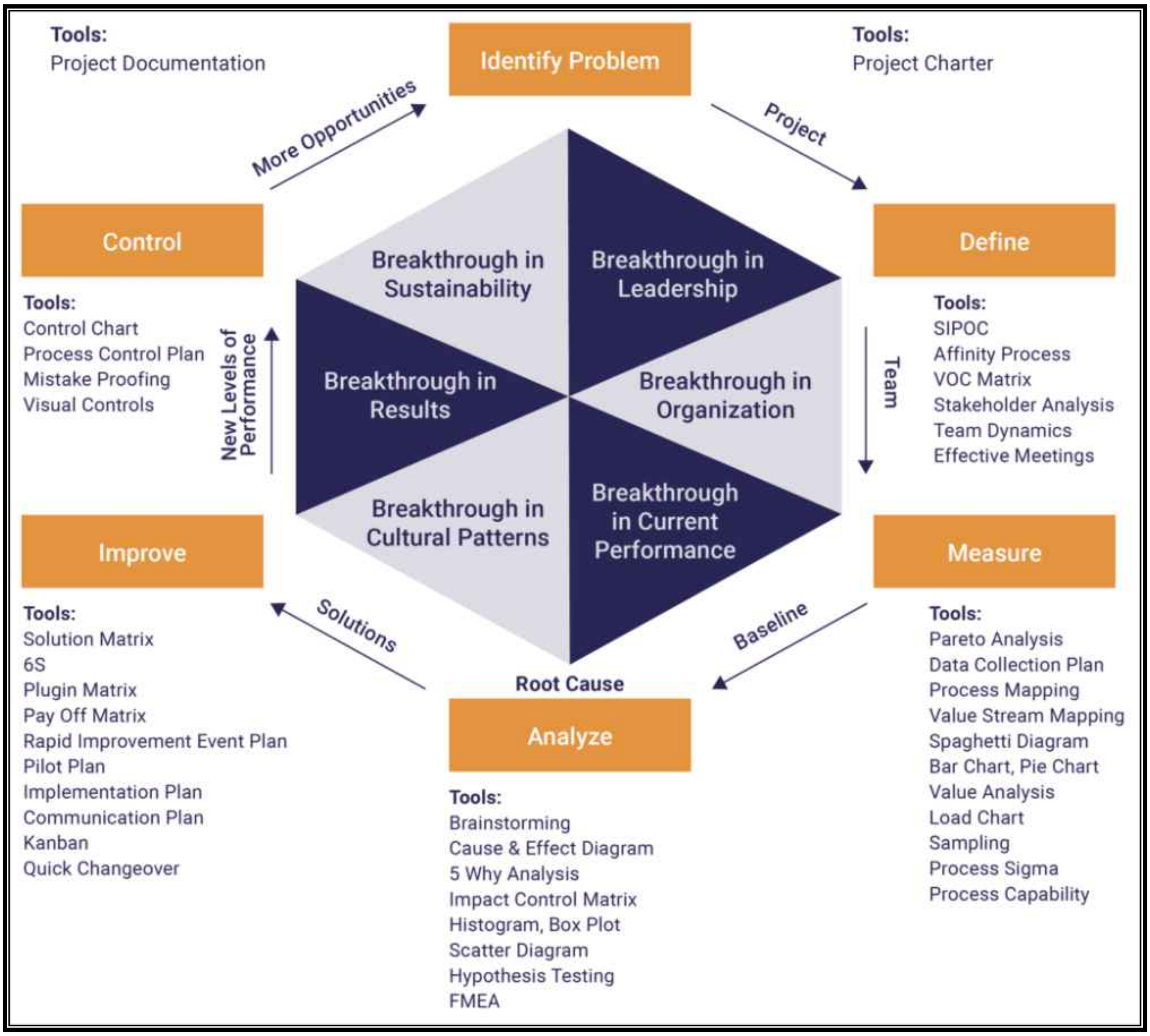



**Fig. 1.** DMAIC Cycle [5].

DMAIC is systematic and fact-based, with a rigid structure for results-oriented project management. Even though the approach appears to be linear and clearly stated, it should be noted that the finest DMAIC outputs are attained when the process is flexible, hence avoiding needless stages. Iterative approaches may also be necessary, particularly if team members are inexperienced with the tools and procedures. The DMAIC methodology takes a problem that has been identified by the company and uses a set of tools and processes in a logical way to find a solution to the problem. The solutions found will reduce or remove the problem resulting in a competitive advantage for the company. This structured problem-solving methodology aims to achieve refined procedures, reduced errors, and elevated performance. Prominent organizations, such as the American Society for Quality and the International Society of Six Sigma Professionals, assert that DMAIC provides a systematic and data-driven strategy for addressing intricate challenges within an organization. Its ultimate goal is to drive improvements and optimize the overall performance of processes, making it a highly regarded strategy for operational excellence. In the "Define" phase, the project team sets project goals, provides a comprehensive description of the problem, and identifies the requirements of stakeholders. Transitioning to the "Measure" phase involves the collection of data regarding the current state of the process, the establishment of performance metrics, and an assessment of process stability. Subsequently, the team advances to the "Analyze" phase, employing statistical methods and tools to uncover the root causes of problems and gain a deeper understanding of their impact on the process. The "Improve" phase primarily focuses on implementing solutions and making necessary process enhancements. According to sources such as the Institute of Industrial and Systems Engineers, this phase often incorporates financial analysis to evaluate the potential benefits of the proposed changes. During the "Control" phase, the project team develops a strategy to sustain the improvements, monitors the process, and implements safeguards to prevent any potential regression. By employing the DMAIC methodology and drawing upon credible sources, organizations can make informed decisions, streamline their operations, and ultimately enhance their competitive edge while ensuring customer satisfaction [6, 7].

### 1.2. Quality and Automotive Sector

The automotive company operations are expanding simultaneously, as component innovation is continuous, which indicates that production quality control needs to be increased throughout. Scrap data management plays a critical role in focusing understanding of the main production issues and enabling prompt action to improve procedures, reduce scrap expenses, and promote a continuous improvement culture [3]. Particularly in the area of quality, the automobile industry has been essential to the advancement of humankind. It was one of the first industries to realize that improving one's performance alone would not be enough to establish and maintain competitive market positions. A company that wants to stand out must compete with peers on an equal technological footing and aim to be among the best. The automobile industry uses several standards to ensure that products meet the necessary level of quality. Leading international corporations now more and more support "business excellence," claiming that producing superior goods is the only way to attain effectiveness and efficiency. To improve quality, a wide range of techniques and procedures are used in the automobile sector. These include ideas, approaches, procedures, research, and instruments, all directed toward the shared objective of raising the standard of living. A quality policy acts as the foundation for a company, outlining its core values and goals related to quality. It is a crucial part of an organization's overarching policy and must be in line with its purpose, goals, and strategy. Moreover, appropriate tool selection and well-coordinated use are essential for the efficient use of quality tools, which are a component of the quality management system. To put it simply, attaining excellence in the automotive sector is closely linked to the quest for unmatched quality, and this path necessitates the application of suitable instruments for quality improvement together with a clearly defined plan.

### 1.3. Cost of Quality

Businesses are finding it essential to focus on quality cost management in an era characterized by greater globalization, fierce market rivalry driven by major technology developments, and digitalization. This strategy includes improving the quality of the product in addition to cutting expenses and raising earnings. Many businesses continue to be ignorant of the complete range of expenses connected to quality over time, the actual cost of poor quality, and the revenues lost because of high-quality costs. Organizations may identify operational flaws and assess the efficacy and efficiency of their programs, processes, and quality-related activities by understanding and implementing the idea of quality costs. The money spent on quality-related activities and management initiatives, as well as on correcting subpar quality, is referred to as quality expenses. As such, they play a major part in the operational, tactical, and strategic management of businesses. Notably, studies have demonstrated that obtaining greater quality levels does not always need spending more on prevention and evaluation; rather, higher overall quality levels are linked to lower total quality costs. When it comes to cutting overall quality expenses, prevention costs have a greater influence than appraisal costs. It's also critical to recognize that the cost of quality can be an effective tool for measuring overall business performance, creating complex quality management systems, evaluating the effectiveness of quality management programs, and determining whether new products will be financially viable before going on sale. Even though academics are very interested in quality costs, there is still a significant lack of information in the literature on the justifications for adopting quality costs, the advantages, and difficulties of doing so, how quality costs are measured, and the importance of different components of quality costs. Research, both theoretical and empirical, has not given these topics enough attention [8].

Even if some expenditures like personnel, supplies, buildings, machinery, and transportation cannot be avoided, there are other costs involved with error prevention, detection, and correction. This brings up the moral dilemma of whether clients should foot the bill for mistakes made by others. In the current business environment, some clients are putting pressure on their suppliers to reduce internal expenses so that they can provide goods at a reduced cost. Although the goal is admirable, this strategy runs the danger of damaging the sector by driving suppliers out of business. Promoting cooperation between suppliers and consumers, wherein the two sides identify and execute cost-saving strategies, is a more efficacious approach. This cooperative strategy should be maintained until neither side is able to find any more savings, indicating that the goal has been reached. It is critical to understand that customers lose nothing when they force their suppliers out of business [9, 10]. As such, the topic of whether quality is truly free continues to be intricate and nuanced. Companies generally aim to improve or maintain better quality while increasing the overall efficiency of the related process. Figure 2 refers to the risks of defining an optimal trade-off between error prevention effort and cost from the result while recording the errors. production with a low number of quality flaws, even "zero-defect" production, is an attainable aim. However, substantial effort is required, such as the physical evaluation of product qualities with high (temporal and spatial) resolutions and the development of adaptive control regimes based on recognized quality gates. Furthermore, the amount of product variants complicates quality inspection planning and implementation. As a result, as the sophistication of error prevention increases, the cost of prevention and assessment increases significantly [11].

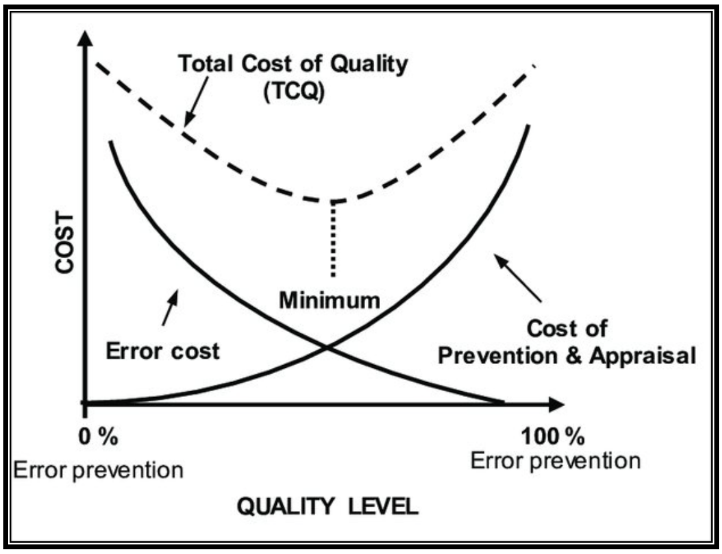



**Fig. 2.** Quality Level and Cost [11]

In summary, organizations must understand the notion of quality costs, which includes both external and internal failure costs. When goods, components, or services don't meet quality standards and are found out before the product is delivered to the client, internal failure costs result. These expenses consist of downtime, yield losses, scrap, rework, retest, failure analysis, and downgrading/off spacing. However, external failure costs which include complaint adjustments, returned goods or materials, warranty fees, liability expenses, and indirect costs associated with unhappy customers occur when delivered items fall short of consumer expectations. The purpose of quality-cost assessments, which range from 4% to 40% of sales, is to minimize the costs associated with internal and external failures by highlighting the need to invest in preventive and appraisal. The leverage effect shows how investing money in evaluation and prevention may save a lot of money by lowering the cost of failure. For continual improvement, quality expenses must be analyzed and reported. Pareto analysis is frequently used to identify the main issue areas. Effective quality-cost initiatives prioritize chances for improvement above simple scorekeeping and demand a dedication to prevention, with a threshold of 5% to 6% of revenue being ideal. In general, in order to improve operational effectiveness and customer satisfaction, businesses should always endeavor to evaluate, assess, and minimize quality expenses [12].

### 1.4. Definition of Wastegate Actuator

The pursuit of improved combustion engine efficiency has been a subject of study for several years. A common technique for increasing the power output of diesel and spark-ignited engines is turbocharging. It offers a cost-effective way to increase a vehicle's fuel economy when paired with downsizing. To achieve optimal engine performance and drive ability over the whole operational spectrum, the turbocharger must be controlled effectively. The wastegate actuator is the most prevalent form of actuator used to carry out this control on the turbine. Despite having a large impact on controller performance, the wastegate actuator has received very little attention in the literature to date. Utilizing a variable wastegate system makes it possible to employ cutting-edge tactics, such as increasing wastegate opening to reduce pumping losses and, in turn, fuel consumption. This necessitates a control strategy where the throttle is kept fully open and the wastegate alone controls boost pressure and engine torque for engine running positions when intake pressures are greater than ambient conditions. The development of boost pressure controllers is generally subject to higher demands due to the quest for improved performance and increasingly complex system configurations. Typically, the engine control unit governs a pressure actuator, which interfaces with a pressure-mixing solenoid valve to regulate the wastegate's opening as required. Measuring this position accurately proves challenging, and its response to control inputs, both in static and dynamic scenarios, is influenced by the engine's operational conditions. Developing a comprehensive physical model for the pressure actuator and pressure feed system is intricate, as it demands a thorough understanding of various factors, including membrane sizes, flow rates, valve areas, and their responses to control signals and actuator positions [13, 14].

With each study, new set values, components, and even structures have been developed to enhance combustion engine efficiency and power, as different focus areas come to the forefront. Turbochargers are one such focus area. Among their critical components, the wastegate plays a pivotal role in controlling boost pressure. The location of the wastegate valve itself influences the flow distribution between the turbine and the wastegate. The operation of the wastegate starting after the turbine is depicted in Figure 3. The angle of the figures gives the impression that the reader is being hit by the exhaust flow coming from this turbocharger component. As shown in Figure 3, when the wastegate is closed, the whole exhaust gas flow is channeled into the turbine, speeding up its rotation and allowing the compressor to produce more boost pressure.

**Fig. 3.** Closed Wastegate [15]

There is less power supplied to the compressor as a result of a bigger amount of the flow being diverted through the bypass rather than the turbine for the open waste case which is shown in Figure 4 [15].

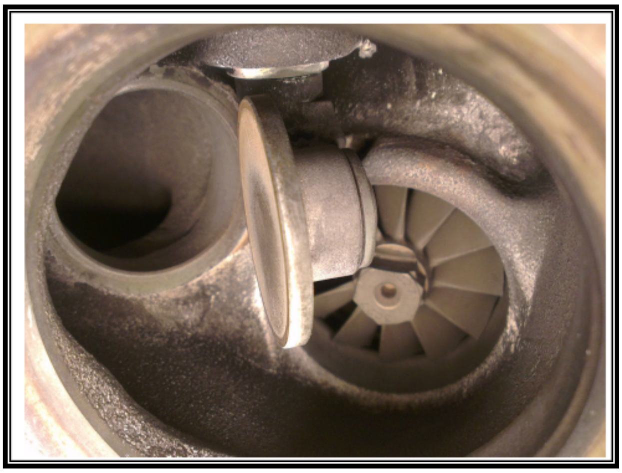


**Fig. 4.** Open Wastegate [15]

One of the initial applications of the wastegate actuator involves a mechanical valve that is actuated by the engine's vacuum pressure, allowing it to open and close. As the engine's rotational speed increases, the electric wastegate actuator restricts the charging pressure to a specific value. Moreover, the wastegate valve's opening level can be adjusted as needed to ensure that the turbocharger consistently delivers the required boost pressure. As a result, there is an increasing inclination toward using electricity to regulate the valve's position by altering its angle in order to minimize fuel consumption. Wastegate actuator placement in a regulated two-stage turbocharger system layout is given in Figure 5 [16].

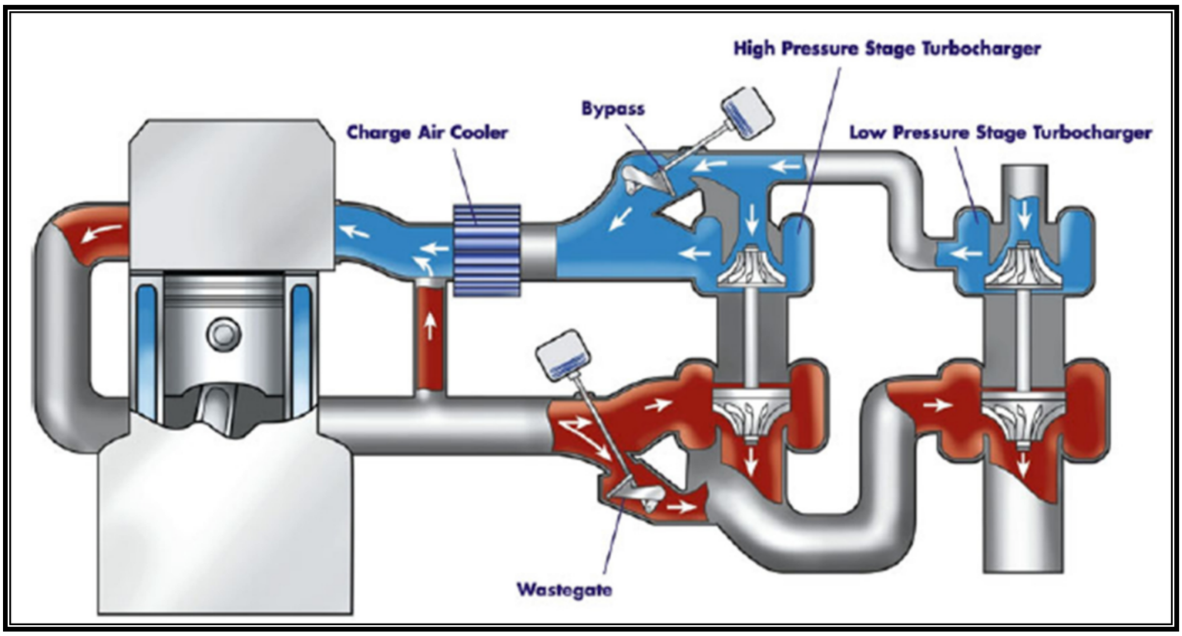



**Fig. 5.** Place of Wastegate in Turbocharger System Layout [17]

## 1.5. Identifying Issues in the Wastegate Actuator Production

WGA new generation actuates the wastegate flap in turbocharged gasoline engines and controls the turbocharger valve under challenging conditions. WGA regulates the turbocharger valve of gasoline engines with turbocharging and moves kinematics in tough situations. As was previously recognized, the turbocharger is a crucial part that uses the energy from exhaust gasses to compress and pull in new air for burning. This clever technique makes it possible for more oxygen-rich air to reach the combustion chamber, which improves engine performance and increases engine torque. Put simply, an exhaust gas turbocharger is made up of two essential parts that are joined by a central shaft: an exhaust gas turbine and a compressor turbine. The compressor turbine is propelled by the exhaust gas turbine, which is powered by the engine's exhaust gas flow. The actuator for the turbocharger sometimes called the control box or boost pressure regulator, is an integrated electronic control unit designed specifically for adjustable turbochargers. Variable Nozzle Turbine (VNT) and Variable Turbine Geometry (VTG) turbochargers are where it is most commonly used. In the context of variable turbine geometry turbochargers, the actuator is essential to maintaining accurate and consistent guide vane control. This then coordinates the modification of exhaust gas flow onto the turbine wheel, which modifies the boost pressure to match a wide variety of speeds. The necessary boost pressure follows a preset map that is kept in the engine management unit and is sent as a signal across a data bus link to the turbocharger actuator. The actuator then positions the guiding vanes in line with the signal's defined angle setting to provide the best possible boost pressure management. The following signs might indicate an electromechanical turbocharger actuator malfunction:

- Reduced performance,
- Inadequate acceleration,
- Engine warning light,
- Decreased vehicle speed,
- Emergency mode,

The wastegate actuator assembled version is shown below in Figure 6.

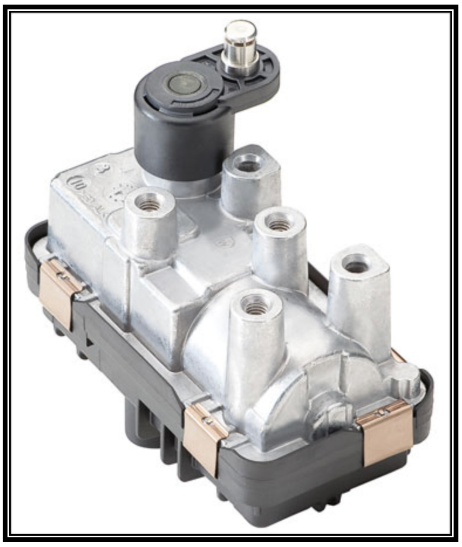


**Fig. 6.** Wastegate Actuator-Assembled [18]

Advanced technology robots, equipment, and sensors are used in the WGA assembly production line in company X. Generally, the assembly line in company X is an Automated Mounting System (AMS) mass production is carried out. As it is seen in Figure 7 9 different modules there are in WGA automated assembly production Also, the WGA line has Automated Optical Inspection (AOI) checkpoints in different stations. These checkpoints are evaluated by specialists regarding customer requirements, and internal or external relevant standards. Besides this different camera system or laser sensor system is implemented to check or detect NOK parts at the line automatically [18].

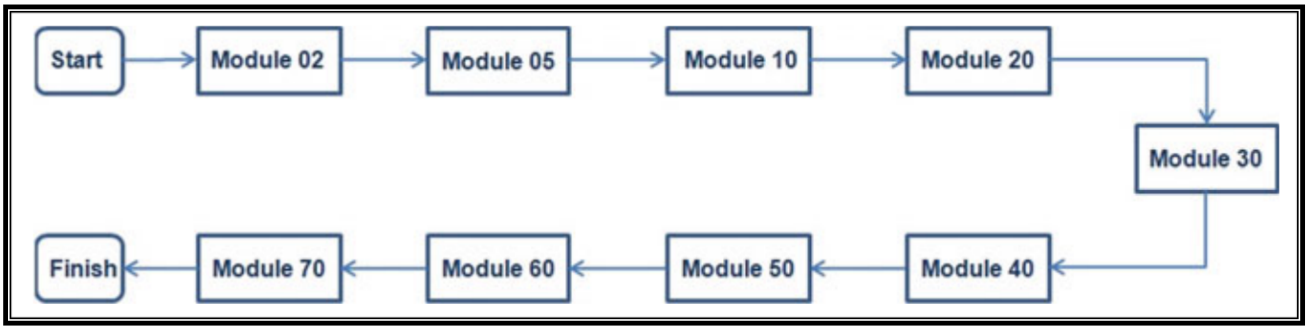



**Fig. 7.** WGA Production Flow Chart [19]

The WGA final good has components as it is seen in Figure 8. To produce the final good of WGA at each station these components are placed into the housing correctly, this activity could be done by the operator manually or by machine or robot automatically. The line starts with the assembly of components into the upper housing cover, then the pressing process in which the printed circuit board is pressed into the cover. During this process, the equipment creates a pressing curve after each pressing process to check by itself. According to this data system sends information to other systems as a pass or fail. Parts get status after each operation, and it is visible in the system and is used for traceability of the part. After this, the upper housing cover and gearbox housing that have different components on each of them are welded to each other. As a next step, the other main station is the EOL (end of the line) test station. EOL test is done in line by an automatic system in this station, each part is tested before shipping out to the customer to ensure that product functionality is working properly. In addition to all this, a visual check is done by an operator before the parts are packed.

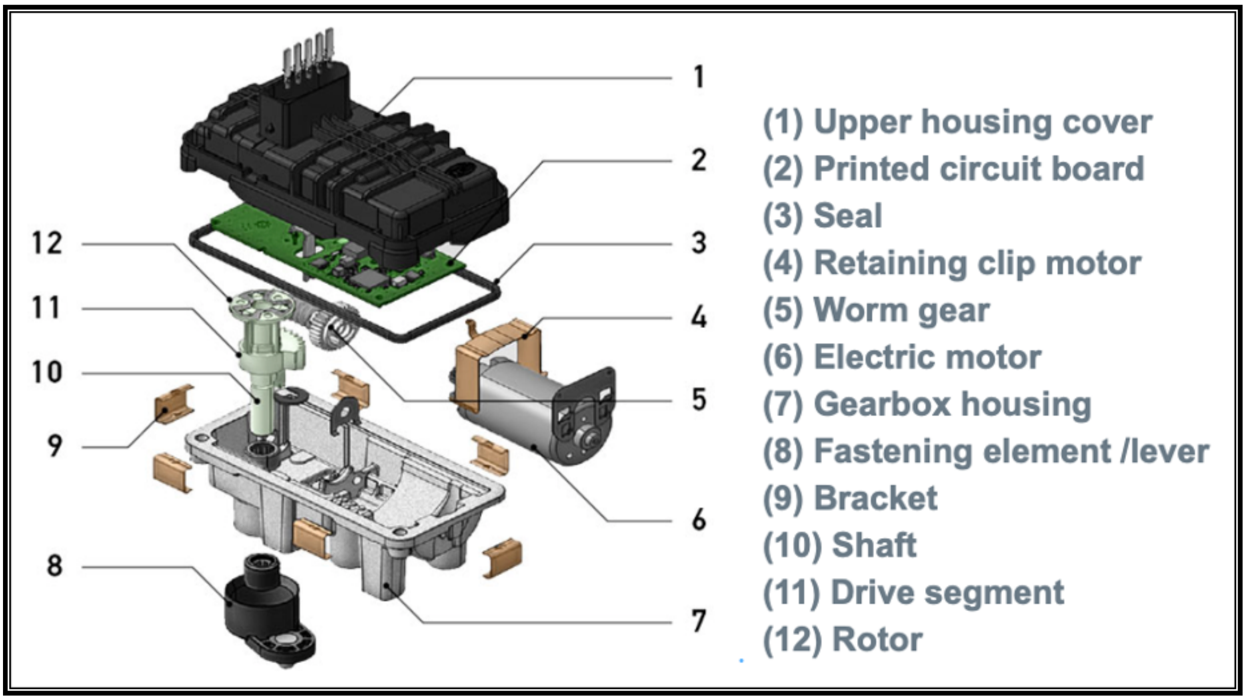



**Fig. 8.** Structure/design of the Company X WGA [18]

During all these process steps different types of failures can occur at the WGA assembly line time by time. A list of potential failures or issues name is given in Table 1.

**Table 1.** A List of WGA Assembly Potential Failures/Issues

| | | | |
|---|---|---|---|
| 1 | Laser Marking Failures | 9 | CE Pressing Failures |
| 2 | Scada Booking Failures | 10 | Output Cover LW Failures |
| 3 | Axles Pressing Failures | 11 | EOL Failures |
| 4 | ITAC Booking Failures | 12 | Laser Marking Failures |
| 5 | Screw of the Fix Element Failures | 13 | Dropped parts |
| **6** | **Suppression PCB Failures** | 14 | Scrap in lines |
| 7 | Sensor PCB Pressing Failures | 15 | Others |
| 8 | Laser Welding Failures | | |

## 1.6. Defining the Scope of the Wastegate Actuator Assembly Process Improvement

Attempts to improve the Wastegate Actuator (WGA) assembly procedure require a careful characterization of the project boundaries, goals, and components. The following steps provide a methodical process for this necessary step. First and foremost, it is imperative to do a thorough analysis of the present WGA assembly process. This will enable the discovery of inefficiencies, bottlenecks, and areas that are prime for improvement. Additionally, performance data and relevant metrics will be carefully collected. Consequently, the improvement initiative's cornerstone is to formulate clear and specific objectives that explicitly articulate expected outcomes, such as increased efficiency, and improved product quality. In order to assess the success of a project, it is essential to define key performance indicators, with measures such as assembly time and defect rates acting as specific benchmarks. A realistic and attainable scope must take into consideration resource limits, which include things like staff availability, time restraints, and financial constraints. Putting all of the above into a structured framework through the production of a thorough scope statement gives the improvement endeavor clarity regarding the project's objectives, boundaries, stakeholders, metrics, and pertinent limitations. In conclusion, it is imperative that all participants in the WGA assembly process have a clear understanding of the specified scope. This will ensure that all stakeholders are aware of the set objectives and restrictions, which will promote collaboration and synergy [20, 21].

By following these systematic processes with the DMAIC quality improvement approach, a strong basis is established for the Wastegate Actuator Assembly Process Improvement. This methodical strategy not only directs the project's course but also increases the likelihood of achieving favorable results. Therefore, the goal is to use the DMAIC methodology to find the most important failure that happens on the WGA assembly line within a given timeframe. To do this, the problem must be analyzed, the core cause must be found and solved, and tracking of sustainability must be performed and put in place to manage the results. In conclusion, the project's goals are to increase assembly line productivity and reduce the amount of scrap that results from the wastegate actuator assembly process. The goals include decreasing the rate of scrap, increasing overall productivity, and minimizing mistakes. Raising line the first pass yield percent from 99.42% to 99.5%, cutting the scrap amount from 218 pcs/week 5 pcs/week, and reducing the scrap rate are the stated improvement aims. The project's scope entails a thorough investigation of wastegate actuator assembly process defects, with an emphasis on locating and resolving the primary root cause of the problem. Within four months, the goal is to provide a process-improving solution that lowers scrap rates and scrap that is linked to the root cause that was found using the DMAIC technique.

### 1.7. Chapter Summary

The goal of the research topic was to improve the WGA assembly process in the automotive sector by addressing the issue of high scrap rates that have an impact on overall efficiency and product quality. The DMAIC strategy was applied in response to the research topic, which highlighted the requirement for a statistically based quality control system. The fundamental design comprised the methodical use of statistical analytic methods, such as Ishikawa diagrams, Pareto charts, control charts, Process Feasibility Analysis, and Design of Experiments. The main conclusions showed that the main problem impeding first-pass yield (FPY) objectives was suppression PCB pressing failure. Throughout the investigation, the well-respected Six Sigma technique DMAIC was methodically used. Although the Measure phase concentrated on gathering information and evaluating process stability, the Define phase established project goals and identified stakeholders. The goal of the Improve phase was to put solutions into practice and improve the process, while the Analyze phase used statistical tools to identify the core causes of issues. Preventing regression and maintaining gains were the main goals of the control phase. The research provided valuable perspectives on optimizing the application of Statistical Process Control (SPC), specifically tackling obstacles in the Suppression PCB pressing procedure. Along with emphasizing the value of business excellence, quality standards, and the use of appropriate instruments for quality improvement, it also highlighted the larger context of quality management in the automotive industry. The investigation found a number of possible assembly line malfunctions, including suppressed PCB problems, laser marking, and screw failures. The DMAIC technique was used to establish the improvement initiative's scope, which included reducing scrap rates, increasing assembly line productivity, and addressing the underlying cause of the detected problem within a given period. The study concluded with a thorough analysis of the WGA assembly process and a methodical approach to quality improvement. The conclusions and recommendations offered by the study will be of great assistance to the automotive industry in its continued efforts to improve the quality of its products and the efficiency of its operations.

## 2. Statistical Scrap Rate Analysis of the Wastegate Actuator Assembly Process

The rapid development of superior items has created considerable worldwide market pressure. As a result, many businesses are forced to update their quality procedures and develop improved techniques to guarantee that client satisfaction covers all operational procedures in addition to the final goods. A statistical-based quality control technique later known as "statistical process control" (SPC) was popularized to achieve this goal. This approach is part of a comprehensive set of techniques for solving problems that are necessary to achieve process stability and improve capacity through the reduction of process variability [22]. The automotive sector, which is fueled by expanded manufacturing capacity and globalization, places a high value on consumer satisfaction with its goods and services. SPC, which provides a collection of methods for efficient process management and quality assessment, emerges as a critical instrument to satisfy the growing demand. By reducing variability in goods, deliveries, procedures, materials, attitudes, and equipment, SPC is a tactic for enhancing capacity. SPC is utilized in manufacturing, especially in quality control, because of its ability to increase both financial and operational advantages. Control charts are used to assess the stability of a process and are an essential tool for identifying circumstances that are inside and outside of control. The key difference is whether the probability distribution that represents the quality attribute changes over time or stays constant. The study explores the use of variable and attribute control charts in process or product parameter control, providing further details on their applications. Process capacity analysis is an important technique for continuous improvement. It uses several capability indices to assess a process's ability to satisfy specifications. This research uses statistical methods to improve process quality and solve quality issue at the WGA Assembly line. A qualitative technique is used in the study methodology to analyze how SPC is implemented and how it affects business success [23]. The purpose of the paper is to provide insights on potential enhancements in SPC use. It focuses specifically on researching and enhancing the SPC philosophy's use in the suppression PCB pressing process of plants that produce automobile components.

### 2.1. Statistical Analysis Tools and Methods for Under-Consideration

Statistical analysis tools comprise a collection of quantitative methods and techniques utilized for the analysis and interpretation of data. These tools offer a systematic means to examine patterns, trends, and relationships within datasets, thereby supporting informed decision-making grounded in empirical evidence. The array of statistical analysis tools spans various methodologies, encompassing descriptive statistics, inferential statistics, regression analysis, and more. Within the scope of this study, the DMAIC approach and its associated tools are employed to analyze the targeted process. The incorporation of statistical analysis tools into the DMAIC approach ensures that decision-making is consistently grounded in data throughout each stage. This systematic approach not only facilitates a comprehensive understanding of the current state of a process but also directs the identification and implementation of improvements, emphasizing measurable outcomes. The utilization of statistical analysis tools contributes significantly to the overall efficacy of Lean Six Sigma initiatives by furnishing a rigorous and structured framework for continuous improvement. In addition to facilitating a thorough knowledge of a process's existing status, this methodical approach also guides the discovery and execution of changes by emphasizing quantifiable results. In this research, different control charts, measurement systems capability studies, process capability analysis, designed experiments, and many other basic statistical tools were used, and different data sets were collected for each tool. Tools that were selected in each phase are detailed in the below chapter [24].

### 2.1.1. Define Phase - Selected Statistical Tools and Methods

As a fundamental document for the whole project, the DMAIC approach places great importance on the preparation of a Project Charter during the Define phase. This detailed charter outlines the project's name, goal, objectives, team members, scope, and high-level schedule. It helps to define the project's limits precisely, spells out quantifiable goals, names important players, describes team members and their responsibilities, creates a schedule with crucial checkpoints, and admits any limitations, presumptions, risks, and related contingencies. As a guiding document, the project charter ensures that team members and stakeholders are consistently in agreement and understanding throughout the DMAIC process. The project charter was used as a tool to outline the goals, objectives, team members, and schedule of the project.

A graphical tool for quality control and decision-making, the Pareto Chart or the 80/20 rule is particularly useful when there are several possible reasons for a given issue. Pareto charts are very helpful for concentrating attention on the most important problems. Organizations may accomplish more substantial improvements faster by addressing the elements that contribute most to the problem, which are on the left side of the chart (80%). Due to this reason, Pareto chart was selected in this project to decide which failure is more critical to reducing the scrap rate in the WGA assembly line in a short time.

Then SIPOC tool was picked to see all possible influences of this problem. Suppliers, Inputs, Processes, Outputs, and Customers, or SIPOC (Figure 9) for short are an organized process mapping instrument used in the Six Sigma technique. It gives a process a high-level visual representation by highlighting key components and connections. The process's essential elements are represented by the acronym: suppliers, who supply inputs; inputs, which are the materials or data needed for the process; the process itself, which shows the steps involved; outputs, which are the finished goods or results; and customers, who receive the final outputs. SIPOC facilitates the thorough knowledge and definition of a process, allowing teams to pinpoint important elements, possible areas for enhancement, and the process's entire scope. It provides a clear and simple overview of the key components of a system, making it an invaluable tool for process improvement activities. The main process from start to end is added, and then all related suppliers not only for components but also internal or external service providers are defined. Measured variables for input and output, process and customer requirements and lastly the customers are defined in Figure 9. Due to data privacy sensitive information are eliminated.

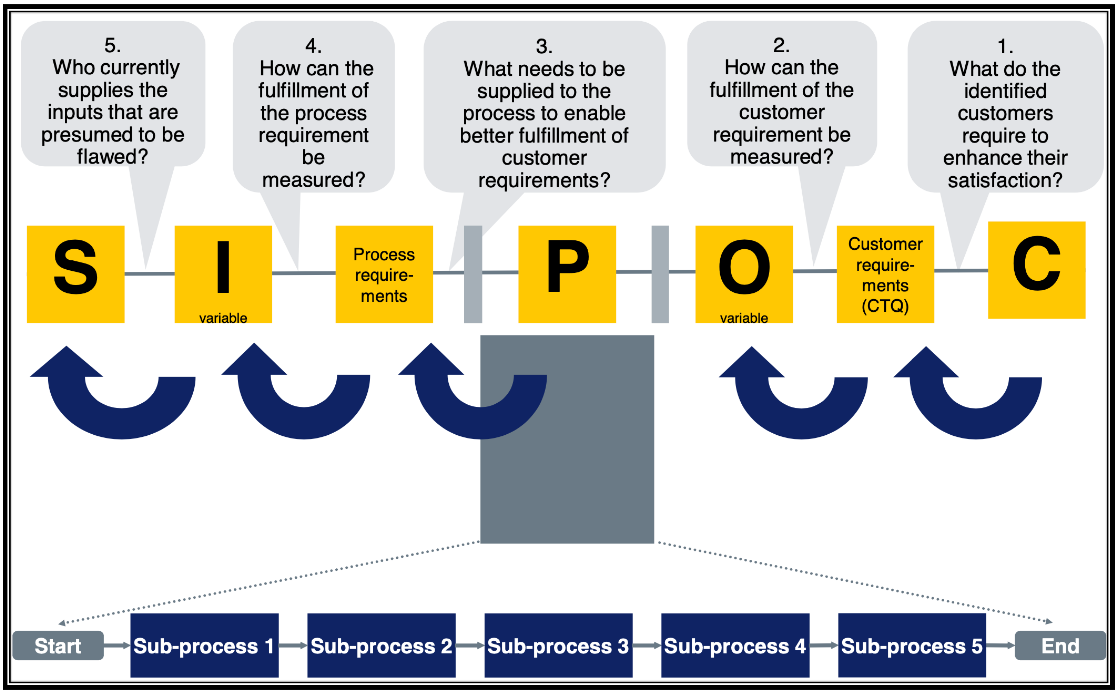



**Fig. 9.** SIPOC Description

Additionally, the 4W+2H (Who, What, Why, When, How much, How long) method was chosen. Using a codified explanation of broad relationships, the 4W+2H questions are a method for thoroughly understanding all elements. Systematically analyzing different elements is essential to identifying and solving an issue. First and foremost, it's critical to identify the individuals or departments impacted by the issue. This entails defining the problem and going into the details of what happened. Localizing the issue is also aided by identifying the location of the issue. Determining the problem's emergence date and the stages it took to appear are equally crucial. It is essential to comprehend the type of issue, how frequently it occurs, how many people are affected, and how it seems. An exhaustive evaluation also benefits from the financial ramifications, which are measured by the expenses incurred. In conclusion, investigating potential sources of the issue is essential to successful problem addressing and resolution. A comprehensive knowledge of the situation is obtained by addressing these important issues, which establishes the foundation for activities aimed at strategically solving problems. Comprehensive answers are provided, for a better understanding of the relationships for this project [25].

### 2.1.2. Measure Phase - Selected Statistical Tools and Methods

Process mapping tools, which give a clear and visual depiction of a process's current condition, are a basic advantage when used during the Measurement phase of the DMAIC technique. Understanding the process's flow of operations, inputs, outputs, and possible areas for improvement is made easier with the help of this graphic explanation. By using tools, diagrams, and flowcharts, team members may identify important indicators for measurement and get a thorough grasp of complicated processes. Additionally, process mapping supports DMAIC goals by facilitating the discovery of inefficiencies, bottlenecks, and opportunities for improvement. It also provides a base upon which to build benchmarks, improve stakeholder and team communication, and direct the gathering of pertinent process data for later measurement and analysis. In essence, process mapping during the Measure phase increases comprehension, makes it easier to identify metrics, highlights inefficiencies, creates baselines, fosters better communication, and directs data collection all of which are essential elements of successful process improvement. Comprehensive process maps were determined as tools for this step in order to define the stages of the current process, the inputs and outputs of each process step in more detail, and to be able to be accurately understood by the entire team.

Using a control chart is quite helpful when it comes to process monitoring. When there are anomalous sources of variability, sample averages that are plotted outside of the specified control boundaries are displayed on the control chart. This event acts as a signal, requiring an examination of the procedure and remedial measures to get rid of these anomalous causes of variability. The implementation of control charts methodically and consistently is a model approach to reducing overall process variability. A carefully designed experiment is very helpful in determining the critical factors that affect the quality characteristics that are being evaluated in a particular process. The controlled input components in the process are systematically changed as part of the defined experiment technique, which enables evaluation of the effect these inputs have on the parameters of the final product. In order to minimize variability in quality attributes and identify the ideal amounts of controllable variables for process performance optimization, statistically planned experiments are essential. Furthermore, using prepared experiments often results in significant improvements in process efficiency and product quality.

Measurement System Analysis (MSA) and process capability tools are advantageous because to can evaluate and guarantee the precision, accuracy, and dependability of measurement systems. By supplying accurate data, MSA reduces measurement mistakes, finds and fixes biases, and improves the general standard of decision-making. Identifying potential areas of variability introduced by measuring systems, helps to improve process control and performance and directs the improvement process.

There are several benefits to using data analysis tools during the DMAIC Measurement phase. These tools show skill in identifying patterns and trends present in gathered data, which helps to validate findings for dependability and correctness. Furthermore, they are essential in providing guidance for evidence-based decision-making and calculating process performance in a meaningful and quantifiable way. The skillful application of these instruments plays a crucial role in obtaining practical understanding, directing the determination of underlying reasons, and aiding in the creation of efficient enhancement plans. In the end, their use contributes to the accuracy and reliability of the analysis, which is crucial for supporting well-informed decision-making when pursuing successful process improvement projects. For all these reasons, not only a data analysis tool was used but also a data collection plan has created a strategy for gathering pertinent data, outlining the types, timing, and methods of data collection.

### 2.1.3. Analyze Phase - Selected Statistical Tools and Methods

For a number of simple explanations, the Ishikawa diagram also referred to as a Fishbone diagram or a Cause-and-Effect diagram is extremely useful during the DMAIC analysis phase. This technique is primarily helpful in the methodical investigation and identification of plausible root causes that underlie a particular issue. It provides an organized method for classifying these reasons into significant groupings, including people, processes, equipment, materials, and the environment. The graphical depiction makes cause-and-effect links easier to see, encouraging teamwork and comprehension during the analytical process. By utilizing the various viewpoints of team members, its use promotes an exhaustive and cooperative investigation of plausible reasons. The Ishikawa diagram helps prioritize and concentrate on important areas throughout the analysis by classifying causes. This way, efforts are focused on tackling the most significant variables that are contributing to the current problem. Furthermore, the diagram's hierarchical style acts as a foundation for problem-solving, assisting teams as they systematically identify and analyze causes following the goals of the DMAIC Analyze phase. The graphic also functions as a tool for documenting, gathering group ideas and Analyze s for communication, future reference, and charting the development of the problem-solving process. All things considered, the Ishikawa diagram is a useful and adaptable tool that makes it easier to conduct cause analysis in the context of the DMAIC Analyze phase in a thorough and organized manner. It was used in this project due to that is an excellent graphical aid for illustrating the possible causes of a specific defect or a specific problem.

### 2.1.4. Improve Phase - Selected Statistical Tools and Methods

A methodical and statistical technique called Design of Experiments (DOE) is used to improve process parameters and pinpoint the key elements influencing a system or process. The use of experimental procedures in DOE facilitates the effective investigation of diverse input components and their interplay to ascertain their influence on the response variable or output. With the use of this approach, which entails organizing, carrying out, and evaluating experiments in a controlled and systematic fashion, ideal circumstances may be found and important variables that have a substantial impact on the process can be understood. DOE is especially useful in situations where a variety of factors affect the result since it facilitates resource allocation, lowers the cost of testing, and offers insights for process optimization and improvement. In this section, this method was chosen to see the effects of the potential root causes determined by the Ishikawa diagram in the previous step, and the necessary conditions and samples were prepared for each situation, experiments were carried out, and the results were observed.

The benefit of using Process Feasibility Analysis is that it can evaluate the viability and practicality of suggested process modifications. Teams can use this study to assess if proposed modifications can be implemented, taking into account technological limitations, possible hazards, and resource availability. Organizations may make well-informed decisions, allocate resources efficiently, and guarantee that suggested changes are feasible and practical given the restrictions by carrying out a comprehensive process feasibility analysis. By reducing the possibility of unrealistic or unfeasible improvements, this proactive evaluation enhances the overall efficacy and efficiency of the continuous improvement process and adds to the success of DMAIC projects. In this project, this methodology was used to evaluate the suggested solution's acceptability considering several aspects, including cost, operational concerns, procedures, and methodologies. Its objectives were to assess related risks and ascertain if the remedy was appropriate in the current situation.

### 2.1.5. Control Phase - Selected Statistical Tools and Methods

In this stage, a thorough control plan was developed, outlining the precise period of time and the data criteria assigned to track the feasibility and sustainability of the suggested remedy. This procedural framework also included statistical control techniques. Once more, information was methodically collected, and examined, and based on the results, an evaluation was carried out to determine whether the original project goals and objectives had been met.

## 2.2. Selecting the Dataset for Statistical Scrap Rate Analysis

The dataset provides the basis for making defensible judgments and putting changes into practice. It usually contains data on the process under study. A variety of data kinds, such as quantitative measurements, qualitative observations, and other pertinent information, can be included in the dataset. Since choices and actions are dependent on the insights gained from the data analysis, the quality and accuracy of the dataset are essential to the DMAIC process's success. In this project main dataset (given in Appendix 1) that includes the failed and produced part amount at the WGA line was collected for a period determined as calendar weeks 31 and 32 and was taken from the ITAC software program. This is created by this software are linked to the relevant material container or serial number. Variable dashboards show inconsistencies that are happening in production. Furthermore, the program guarantees total traceability and transparency during the whole production process.

An additional selected dataset for the analysis is Suppression PCB Pressing curves which provide information about force and trigger distance. These are automatically created at the line after each part production, which is seen in Appendix 2 for this period. Also, pin position and PCB dimension measurement results are used as a dataset but not included in this report due to commercial secret, only results are presented at the DMAIC Measurement phase. Pin height measurement results are used for short-term capability, this dataset is seen in Appendix 3. Also, Appendix 4 is used for the attributive MSA report.

## 2.3. Conducting and Ranking Statistical Evaluation

At the very beginning of the project, the WGA line quality key point indicator (KPI) value was taken as a first-pass yield (FPY). This term is also used to refer to throughput yield or TPY. This is a crucial manufacturing statistic for assessing output and quality. This is associated with how well a process works and how scrap is removed from it. Because of its emphasis on cutting down on waste and inefficiencies, the FPY is also useful for gauging the effectiveness of continuous improvement. The data sets given in Appendix 1 were used to calculate this data for a specific period. The calculation is done according to the definition that the number of units that exit a process divided by the number of units entering it during a certain amount of time is the FPY. As seen in Table 2 WGA Assembly line has a red FPY means that the line is not reaching the targets.

**Table 2.** FPY Result for Each Selected Period in WGA Line

| Period | Pass Part Amount(pcs) | Failed Parts Amount(pcs) | FPY(%) |
|---|---|---|---|
| CW31 | 21989 | 126 | 99.43 |
| CW32 | 15533 | 92 | 99.41 |
| Average | 37522 | 218 | 99.42 |

The same data set was used to create a Pareto chart which is seen in Figure 10. Suppression PCB pressing failure was shown to be the most common mistake manifestation when all faults within a certain time frame were analyzed using the Pareto analysis approach. As is seen in Figure 10, 126 pcs of Suppression PCB failures were obtained from CW31 and 92 pcs from CW32. For this reason, Suppression PCB pressing failure was chosen critical station to investigate and solve by the DMAIC methodology approach in this project. The examination of scrap rates, particularly concerning Suppression PCB press fit failures, is critical to quality control and process optimization. Scrap rates provide important information on the efficacy and efficiency of manufacturing processes as well as the general state of production systems. Because electronic components are so delicate and detailed, examining scrap rates becomes especially more important in the context of Suppression PCB press fit failures. Comprehending the origins and trends of scrap, particularly in connection with PCB press fit malfunctions, furnishes producers with vital insights for focused enhancements. Failures in the PCB press-fit process can result in a variety of problems, from lowered product quality to possible customer discontent. Manufacturers can pinpoint the stages in the production process when flaws or malfunctions arise by focusing on scrap rates linked to PCB Press fit failures. Furthermore, a detailed analysis of Suppression PCB press fit failures in scrap rates enables proactive problem-solving [26].

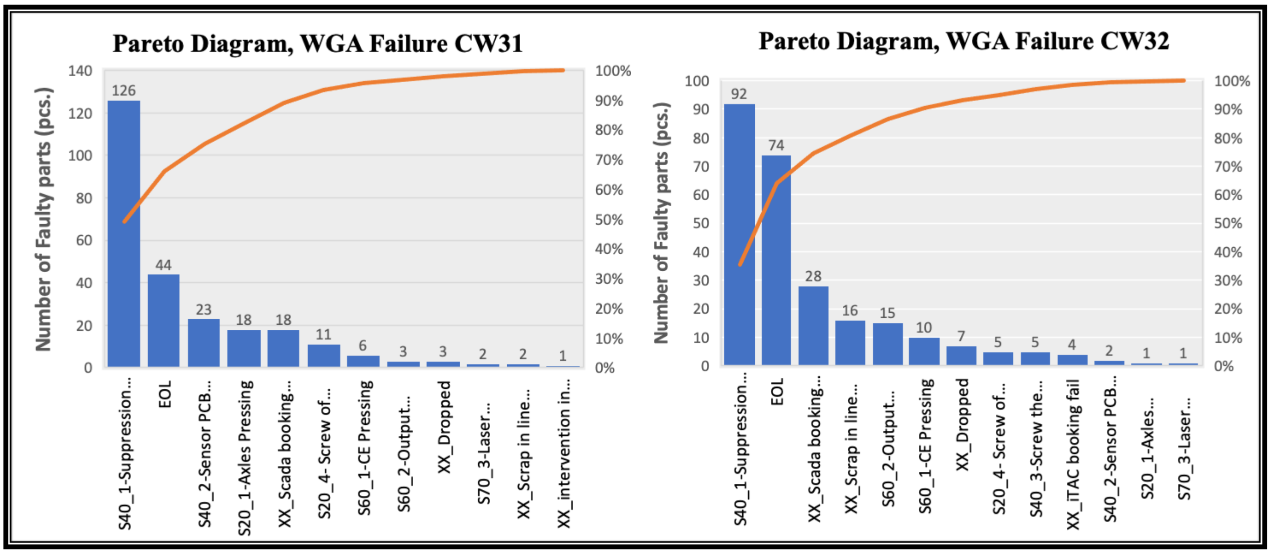



**Fig. 10.** Pareto Chart for CW31-CW32 for WGA Assembly Process

The main process is the press-fit process which is a tried-and-true interconnection technique that is generally recognized for connecting electronics assemblies for the suppression PCB pressing operation. The automobile sector has embraced press-fit technology with adjustable press-fit zones within the last ten years. This technique eliminates heat processes and simplifies process management, among other important benefits. It also allows high-current applications and makes miniaturization easier. Press-fit technology is anticipated to be used more often in a variety of vehicle locations, each with its own set of environmental requirements. Press-fit technology has shown to be a reliable connecting technique for electrical components and connections in these kinds of situations. Press-fit technology has shown that PCBs with immersion tin surface metallization are robust when combined with other materials. This is especially true in the European region. Electrical assembly using press-fit technology eliminates the need for solder. The "compliant" portion of the press-fit pin that is being inserted is somewhat bigger than the plated PCB hole. The compliant part offers the "press-fit" connection when it is compressed and fitted into a PCB PTH (Plated through Hole). A regulated fluctuation in hole sizes is dynamically adjusted by the compliant section. As it is shown in Figure 11.

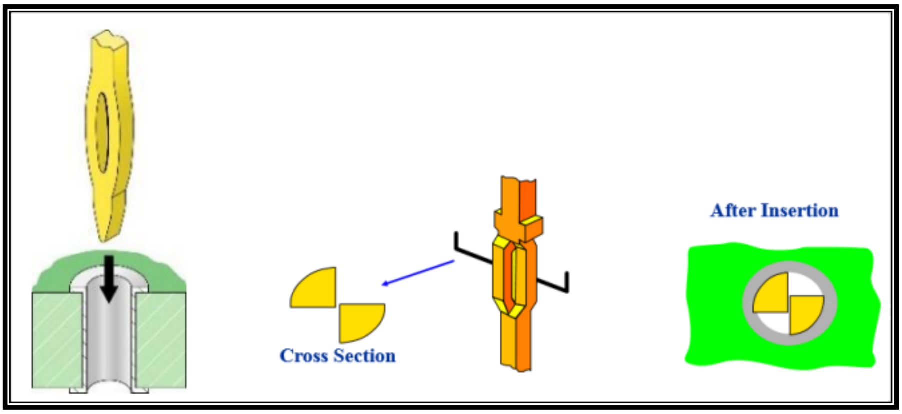



**Fig. 11.** Press fit insertion and cross-section [27]

The following requirements must be satisfied in order to have the best outcomes possible in the press-fit connection which is shown in Figure 12:

- Make sure that the press-fit zone on the PCB is precisely aligned.
- Check to be sure the PCB is not damaged.
- Remove any dust, particles, or flakes that may be present.
- Verify that there are no damages.
- Make sure the force-distance control stays within the allotted parameters.
- Check to see if the pin protrusion is there.
- Meet all mounting group requirements, including those regarding location, pin circularity, perpendicularity, and other particular standards [27].

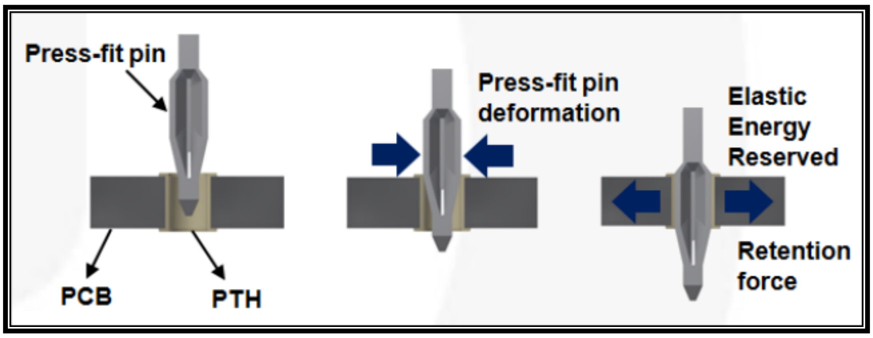



**Fig. 12.** Correct Press-fit Process [28]

The press-in procedure's overall flow is depicted in Figure 13. The press-in tool is made up of two parts: the lower press-in tool includes etched slots to hold the press-fit pins, and the upper press-in tool is typically flat and uniformly in touch with the backside of the module. The tool's two components must line up with one another. PCB and press-fit tool must be aligned with a position tolerance, parallel, and enable a perpendicular insertion of press-fit contacts into the PTHs. Furthermore, depending on the PTH diameter, the press-in force for a single pin should be between 60 and 150 N. The sum of the force needed for a single pin multiplied by the number of pins in a module equals the total press-in force. A press-fit pin may attach to the plate through a hole less securely if the press-in pressures are less than 60 N/pin. The plated-through hole's diameter being too big for the press-fit pins is the main cause of the poor press-fit force. Press-fit terminals, PTHs, and PCB tracks may sustain mechanical damage from press-in pressures of more than 150 N/pin. In compliance with IEC 60352-5 standards, the suggested press-in speed falls between 25 and 50 mm/min [28].

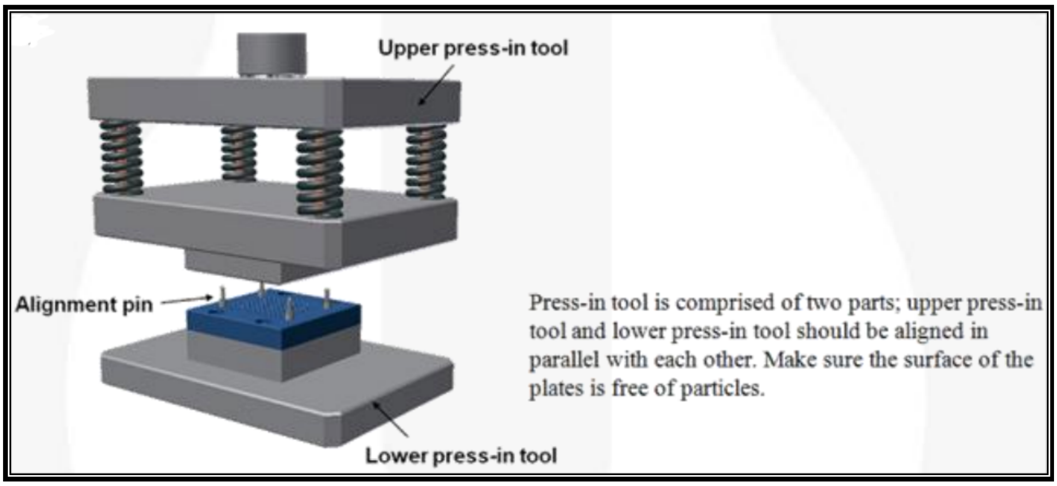



**Fig. 13.** Press-fit Tool [28]

Furthermore, additional measurements which are measurements functioned as a foundational dataset that was essential in identifying the root cause of the observed mistake. This dataset made it easier to conduct a thorough analysis in order to determine whether the requirements specified in the drawings or standards were satisfied. These specifications covered a number of crucial elements, such as pin location, heights, and widths, as well as PCB dimensions and PCB hole width. By using these data, it was possible to conduct a methodical assessment that guaranteed compliance with the established norms and criteria in the context of production or quality control. Apart from the above-stated elements, process capability reports and Measurement System Analysis (MSA) reports on a regular basis were also provided. These were carefully reviewed during the dataset evaluation.

## 2.4. Chapter Summary

The ultimate goal of this completed study was to use SPC, a statistically based quality control approach, to solve the high scrap rate problem in the automotive industry's WGA assembly process. To methodically address the problem, the research used the DMAIC technique, which consists of the stages Define, Measure, Analyze, Improve, and Control. Throughout the investigation, statistical analytic methods such as control charts, Pareto charts, Process Feasibility analytics, Ishikawa diagrams, and DOE were methodically selected to use in further steps of DMAIC. The statistical scrap rate study was based on the dataset, which included measurements of PCB dimensions, pin location, suppression PCB pressing curves, and failed and manufactured components. The main conclusions showed that the most common problem influencing the assembly process was suppression PCB pressing failure. Using FPY as a key performance metric, it was discovered that the WGA assembly line fell short of expectations. The study's contributions are centered on offering perceptions into possible improvements in the use of SPC, with an emphasis on difficulties in the Suppression PCB pressing process of car component manufacturing. During the Control phase, a thorough control plan was created, and the project's initial goals and objectives were assessed to see which of them had been accomplished. Conclusively, this study provides significant insights for manufacturing enterprises in search of organized approaches to problem-solving that enhance quality. It highlights the significance of having a comprehensive comprehension of the procedure and utilizing a range of statistical instruments to ensure effective process management and quality evaluation in the automotive sector.

## 3. Scrap Rate Reduction Solution Applying the DMAIC Approach

The first phase of the DMAIC entails defining the parameters of the project, identifying the problem, and setting goals. The following crucial activities are included in the main goal of the DEFINE phase:

- Clearly define and thoroughly record the issue that has to be resolved, as well as any consequences, and state the intended result without providing a solution in advance.
- Assess the potential financial gains that the project may yield.
- Persuade project coordinators and key team members to take an active role in the project.
- Indicate the parameters and scope of the process that is being examined.
- Determine the needs expressed by the designated clients, which may go beyond the project's original assignment, in order to determine the project's extent.
- Convert client needs into Critical to Quality parameters, which include error definitions and measurement variables.
- Clearly state the boundaries of the project job.
- Examine the projected schedule, amount of work, and important project milestones.

The Define Phase includes gathering input from the Voice of Business (VOB) and the Voice of Customers (VOC), holding brainstorming sessions, examining past data, gathering information, and making use of flow diagrams, processing maps, SIPOC diagrams, and 4W+2H questions. These instruments are used to identify all current issues and determine crucial quality variables, which point out areas that need to be corrected [29].

The method entails figuring out how to measure the issue and then assessing the situation as it stands during the Measure phase. Critical quality elements are evaluated in the measure phase in order to monitor performance indicators that correlate to problems found in the define phase. As a guide, consider the following queries for this phase:

- Which measurements are going to be used?
- Which standards and instruments of measurement will be used?
- Which information is necessary to quantify the issue?
- Are the data obtained trustworthy?
- Has the performance as of late been adequately measured?

This stage examines and measures how well the business process in question is doing right now. By creating a baseline, or the "as-is" condition, this approach creates a point of reference for evaluating the effects of any further enhancements. Metrics like process length, defect count, and cost may be part of the baseline. During the measure phase, several techniques are utilized, including control charts, ANOVA, Pareto diagrams, gauge R&R measures, voice of the process (VOP), capability analysis (sigma level), MSA, and control charts. Before launching any improvement projects, these technologies offer insights into the organization's baseline performance.

During the pivotal analysis, the focus shifts to meticulously examining the data gathered in the prior steps to understand the performance gap that exists between current and desired benchmarks. To identify and document sources of variation, this stage is crucial, while avoiding premature conclusions that might inadvertently introduce new challenges. Discipline is required, urging us to resist jumping to conclusions. Through tools such as the Pareto chart, fishbone diagram, 5Why Analysis, and Failure Mode and Effects Analysis (FMEA), the methodology encourages a thorough investigation into the root causes of the identified issues. Furthermore, these instruments facilitate the elucidation of patterns that are crucial to making informed choices by aiding in the visualization of numerical data. It maintains a holistic perspective to enable effective solutions, laying the foundation to uncover both the intricacies of the problem at hand and latent opportunities for improvement.

Optimizing the process will ultimately result in more productivity, fewer errors, and overall performance improvement during the Improvement phase. Using both quantitative and qualitative methodologies to achieve long-lasting improvements to the process under examination, the Improvement phase is distinguished by a methodical approach to innovation. Verifying that the modifications that have been put into place correspond with the original goals established in the Define phase is the task of the Improvement phase. This stage guarantees that the enhancements align with the project's overarching objectives. Complete documentation of every modification performed during the Improvement phase is required not only for this phase but also for other phases. This involves describing the changes, their effects, and any lessons discovered along the process of implementation. Prioritizing the resolution of the most pressing problems and thoroughly testing suggested solutions are essential steps before a full deployment. Therefore, careful observation of the modified process is necessary to confirm that the expected enhancements have been achieved. During this phase, there are a few frequent dangers that should be carefully considered. These include:

- Choosing to proceed with a less-than-ideal answer rather than the best one.
- Change management techniques are not being implemented well enough.
- Poor use of the Solution Prioritization processes.
- Inadequate use and interpretation of metrics and data.
- Underestimating how changes that are put into place will affect things.
- Readjusting based on a Critical Root Cause that was incorrectly recognized.
- The integration of work standards, instructions for work, and Control Planning processes are not adequately documented.

The improvement phase and the whole DMAIC technique depend on these factors being carefully considered [30].

The Control phase, the last step of DMAIC, where tactics are used to maintain the improvements over time, is made possible by the success of this phase. In order to sustain the benefits made throughout the DMAIC process, the Control phase focuses on institutionalizing the improvements, keeping a close eye on ongoing monitoring, and taking proactive measures to address deviations. This stage specifies the teams or persons in charge, the frequency of monitoring, and the control techniques. Control charts and statistical techniques are combined to track process stability. To guarantee that any modifications or updates to the procedure are successfully conveyed to pertinent stakeholders, communication procedures are put in place. To make sure the procedure is following the set control measures, audits are carried out on a regular basis. It is assumed that industry standards, laws, and client needs are followed. In this stage control charts, SPC tools, FMEA, standard operation procedures, visual checks, audits, Poke Yoke, key performance indicators, and many different useful quality tools can be used.

### 3.1. Define Phase of the Study Project

This research was started by preparing a project charter. In this step, as can be seen in the figure below, what the problem is, the target of the project, the time plan for the project steps, the scope or out-of-scope of the project, and the current situation are determined. The problem was defined as reducing a total of 218 Suppression PCB pressing errors that occurred between CW 31 and 32 weeks on the WGA line, to a maximum of 5 per week at the end of 4 months. Other line scraps were not taken into consideration during the problem-defining process. In order to make sure that everyone on the team understands the challenge in the same way, additional photos or curves were included. It is seen in Figure 14.

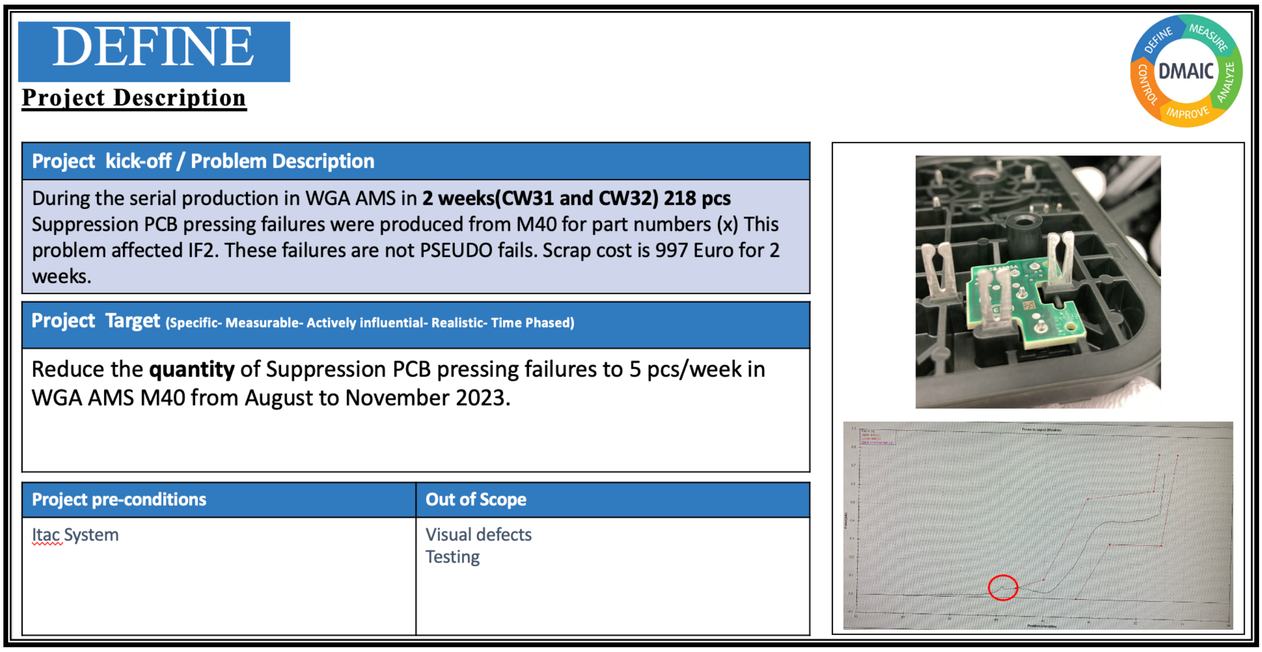



Fig. 14. Project Description

Detailed failure description visualization can be found in Figure 15. In the normal process, any peak should not be seen in the pressing curve but according to this situation peak appeared at the beginning of the process, then the process was ongoing as it should be normally. This situation's root causes were investigated in further steps.

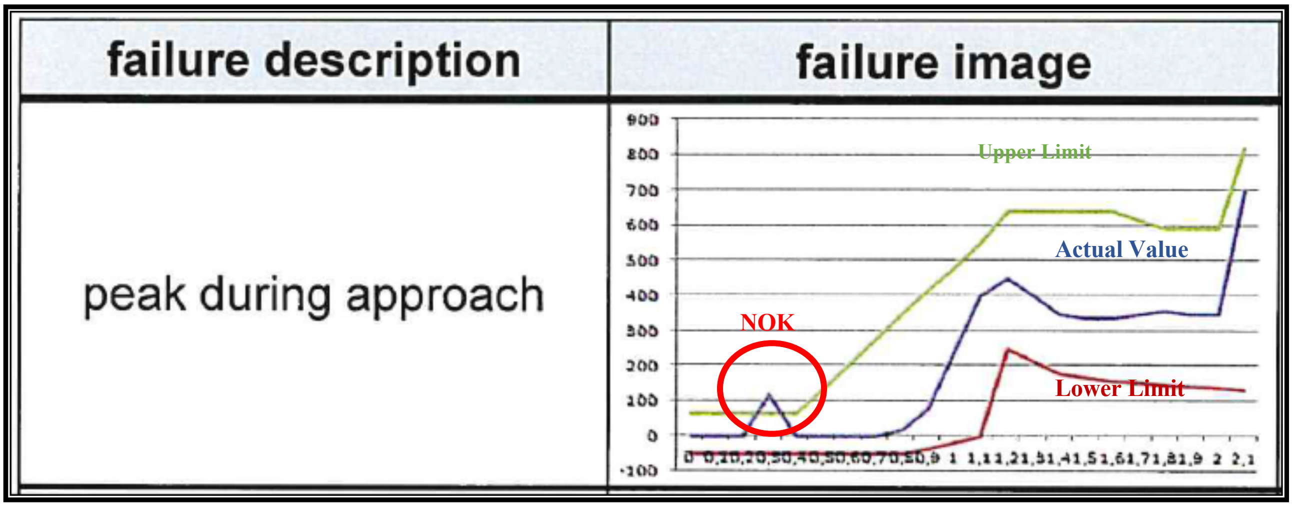
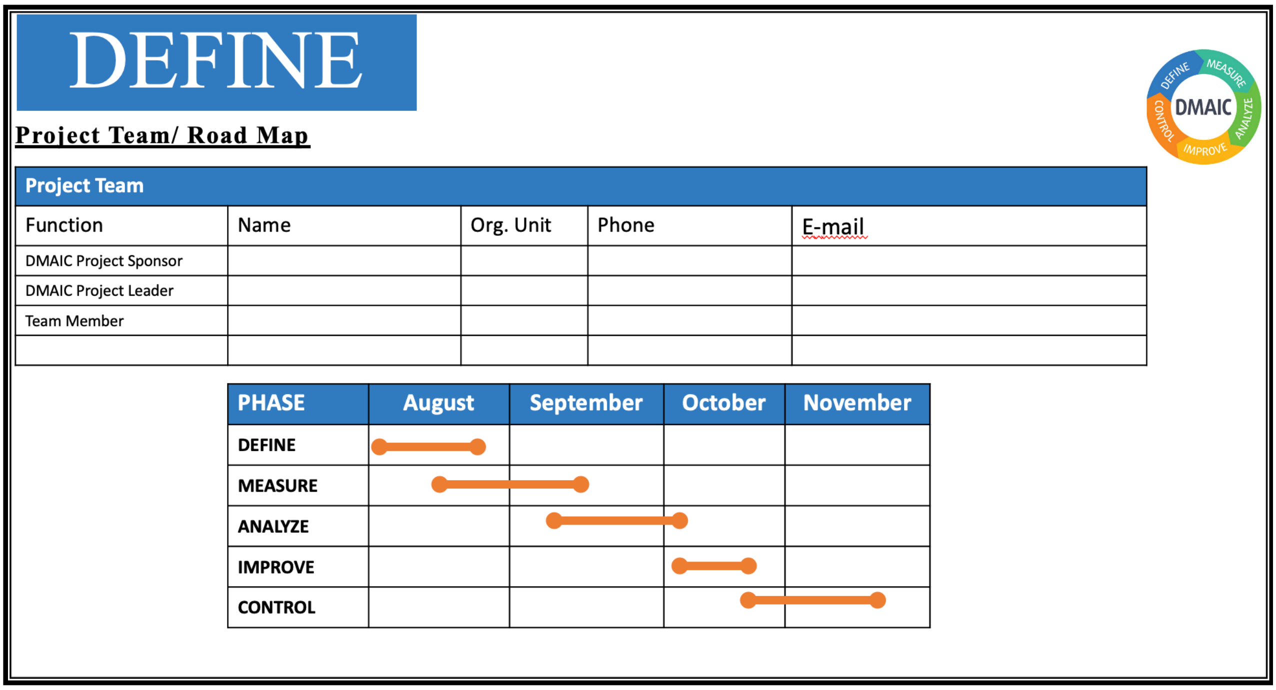



**Fig. 15.** Suppression PCB Pressing Failure Curve

Then the project team who can provide support, information, or knowledge to solve this problem is created and a road map is prepared. During the formation of the team, a person who has completed DMAIC-related training from the quality side, who knows the necessary project steps, and who can use statistical analysis tools, was selected for the team leader, the relevant department manager who provides support for the project was determined as a sponsor, and the laboratory analyst and specialist working in the analyzes were selected among the other team members. Also, the process specialist and manufacturing engineer were included as line owners. Team member's names are deleted from the table due to the protection of personal data. It is seen in Figure 16.


DEFINE

Project Team/ Road Map

| Project Team | | | | |
|---|---|---|---|---|
| Function | Name | Org. Unit | Phone | E-mail |
| DMAIC Project Sponsor | | | | |
| DMAIC Project Leader | | | | |
| Team Member | | | | |
| | | | | |

| PHASE | August | September | October | November |
|---|---|---|---|---|
| DEFINE | | | | |
| MEASURE | | | | |
| ANALYZE | | | | |
| IMPROVE | | | | |
| CONTROL | | | | |



**Fig. 16.** Project Team and Road Map

Then, the SIPOC tool was used, where the process steps were determined in general terms, the station where the problem arose was taken into account, and each relevant supplier was determined not only for the components but also for lines, people, or units. Specific inputs and outputs, requirements, and measurement variables have been added. In addition, customers and customer expectations were defined by taking VOC into account in this step.

# DEFINE

**SIPOC**

| S | I | Process requirements | P | O | Customer requirements (CTQ) | C |
|---|---|---|---|---|---|---|
| **Supplier** | **Measured Variable** | **Requirement** | | **Measured Variable** | **Requirement** | **Customer** |
| XX | Line, | MSA Less than 20% | Assembly of WGA with all components | WGA Electrical Functions | XX | XX |
| XX | Cover | According to PN XX Drawing | | XX | XX | XX |
| Front End | PCB | According to PN XX Drawing | | | XX | XX |
| Maintenance | PCB pressing tool | According to TPM | | Suppression PCB pressing Curve | Suppression PCB press-in into cover XX | WGA Line |
| Qlab | To perform daily NOK parts analysis | Acc. Cover assembly drawing | | | | WGA Line |


**Fig. 17.** SIPOC of Project

As the last step of the define phase, the exact details of the problem were created using the 4W+2H method. It can be seen in Figure 18.

# DEFINE

**4W + 2H Questions**

| Describe Problem | Information resulting from the question | | Additional Explanation |
|---|---|---|---|
| Define the Problem | Suppression PCB Pressing Failures | | |
| Specify the Problem | IS | IS NOT Could be, but is not..... | |
| WHO? | Waste Gate Actuator | xx lines | The problem is occuring in WGA at M40. |
| WHAT? | Suppression PCB pressing Failures | CE pressing failures | Issue is presented several technical issue |
| WHERE? | Plant XXX | Customer | Problem is occured at our AMS lines |
| WHEN? | CW31- CW32 | NA | Problem has been presented weekly, but CW31- and CW32 we got more |
| EXTENT HOW, HOW MUCH? | 218 | 1000 | Reported from CW31 and CW32 |
| HOW OFTEN | weekly | daily | Problem is extented each week |

**Fig. 18.** 4W+ 2H Questions

## 3.2. Measure Phase of the Study Project

At the measuring phase firstly process map is created for this project. The main processes are defined for the WGA assembly production process, it is seen in Figure 19.

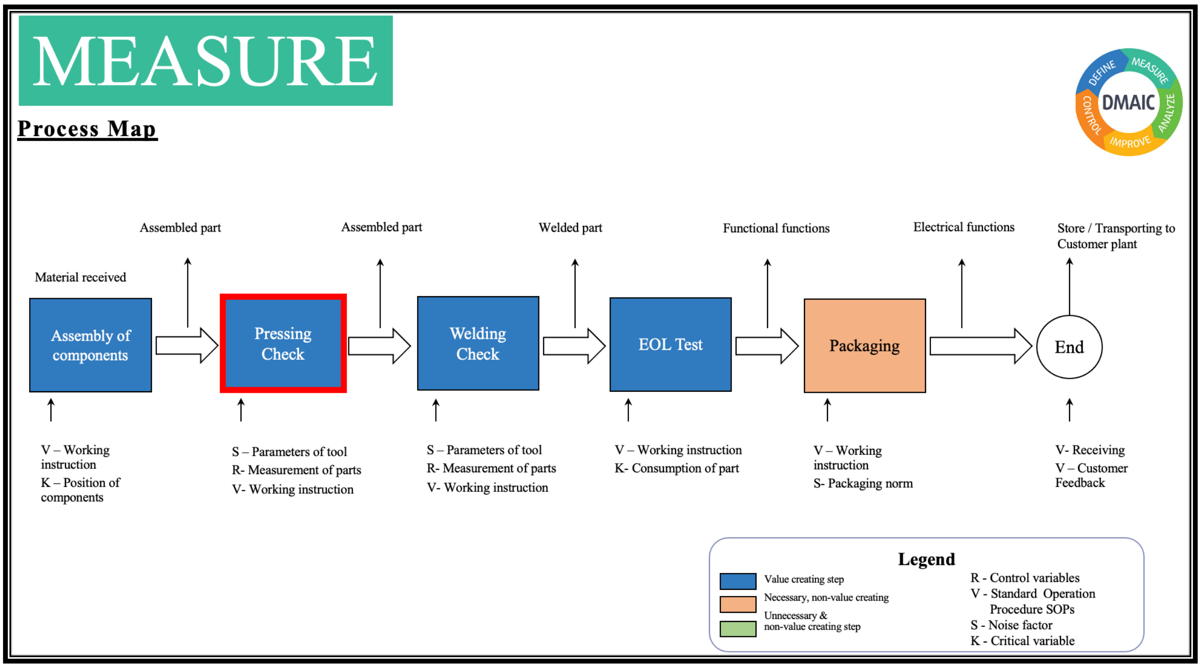



**Fig. 19.** WGA Assembly Production Process Map [18]

Suppression PCB pressing failures appear during the pressing check process. Then to answer the questions which are mentioned above short-term capability and MSA measurements were done, and result reports were checked. For the short-term capability measurement, 50 pcs parts were produced and then measurement was done by a quality analysis specialist according to the drawing requirement. After that, this measurement dataset was used to create a capability report by using the Qs-Stat software program. As seen in Figure 20 short-term capability result was found as a NOK for this process. All measured values were found in the limit but after calculation Cpk value was found less than 1,67 which means that the system is not capable according to the company definition. Changes in proficiency measures may generally be caused by the following factors: machine, measurement, operator, material, environment, and method.

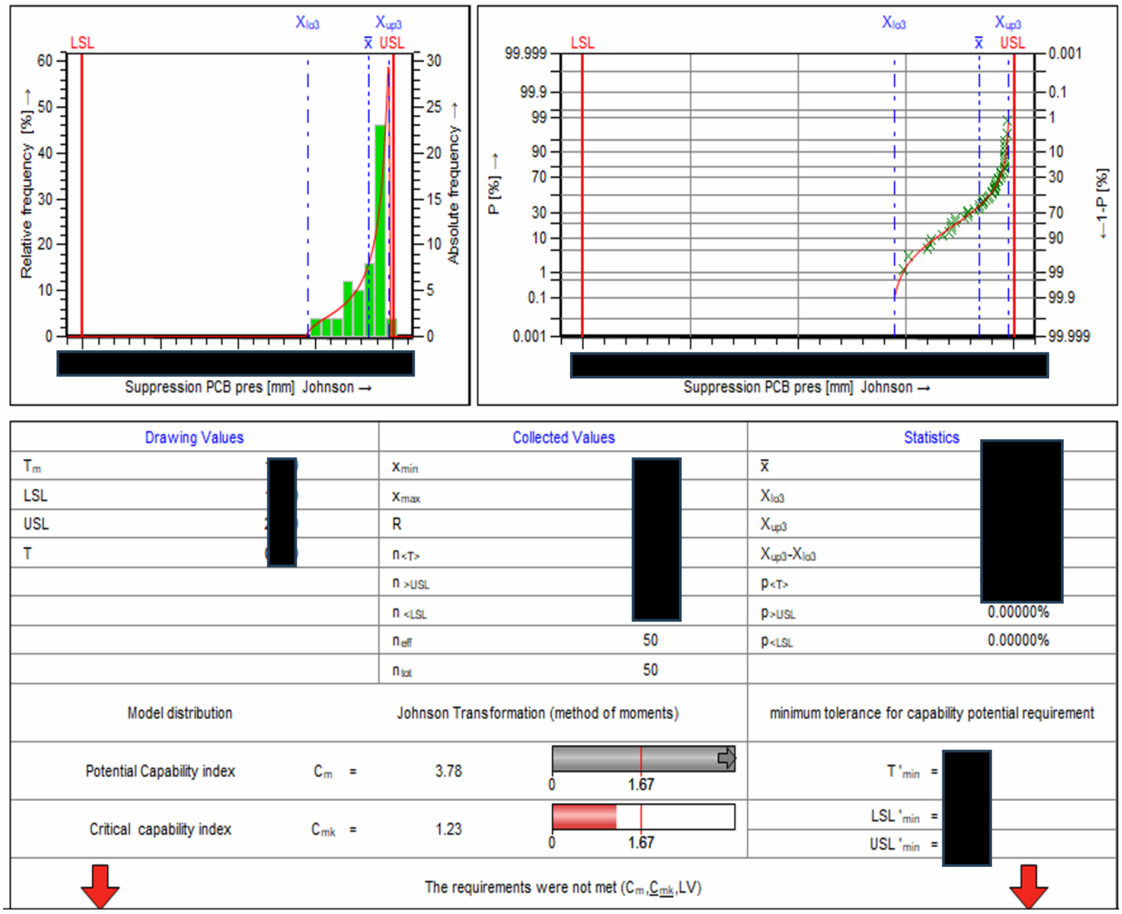



**Fig. 20.** Short-term Capability Report

During this process at this pressing check station, there is an AOI system that automatically checks 100% visually. This visual check means that the system is measuring pin height after pins are pressed into the PCB. That's why to perform MSA measurement, the attributive MSA method was used. For this measurement 20 pcs OK and NOK parts are taken and measured at the station by AOI system. As a next step data are entered into the SOLARA software system to get the result of the MSA report. The MSA report is found as an OK as it is seen in Figure 21.

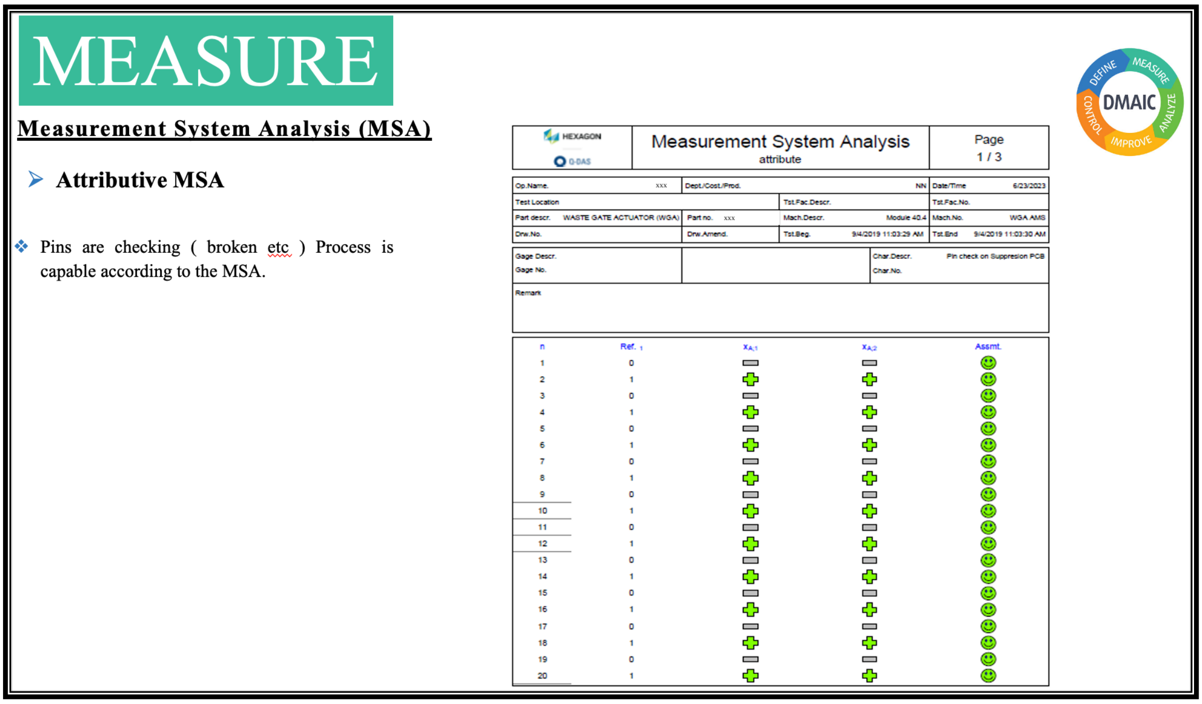
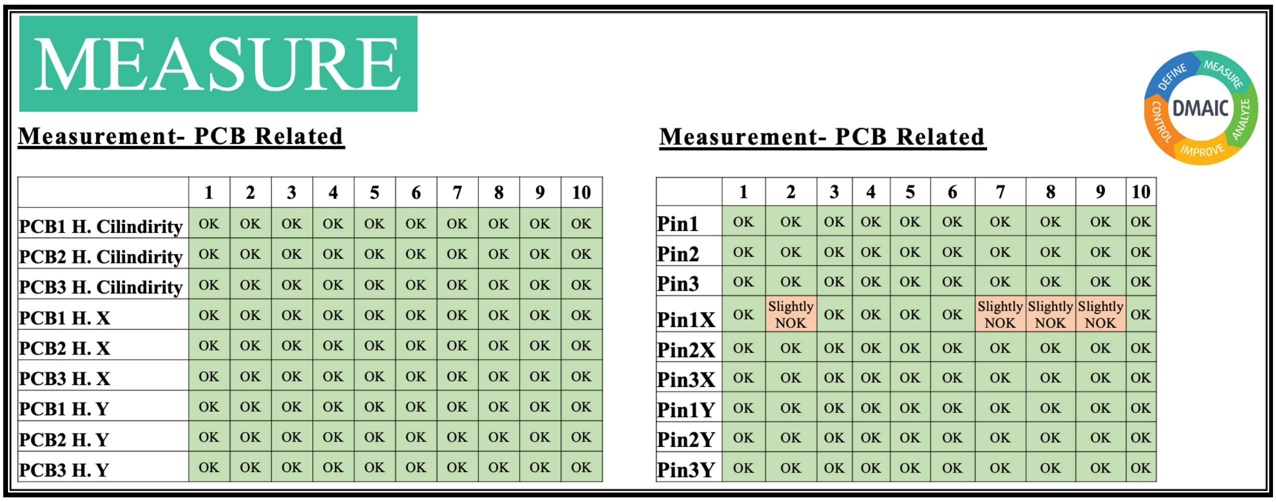



**Fig. 21.** Measurement System Analysis

Measurements of cylindricity and position were made on three holes in each of the ten randomly chosen printed circuit boards (PCBs) for a comprehensive analysis. The observations showed that each PCB hole's cylindricity satisfied the required standards and that the holes' placements were all within the allowed ranges. Ten random housings were ordered at the same time by using a 3D device to measure pin heights and positions in compliance with the specifications shown in the drawings. It was discovered after this assessment that four pin sites' positional precision along the x-axis just barely surpassed the predetermined bounds. However, it was observed that these point parts went out of the limit with a very small value of 0.002, (due to the confidentiality reason, result of measurement not being presented) as a consequence of the 3D machine having the ability to make very precise measurements and there was a deviation approval previously taken within this limit tolerance. In other words, it was decided that such small value differences should be accepted and not taken as the root cause. Measurement results were placed into the table and presented in Figure 22.




**Measurement- PCB Related**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| PCB1 H. Cilindirity | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB2 H. Cilindirity | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB3 H. Cilindirity | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB1 H. X | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB2 H. X | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB3 H. X | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB1 H. Y | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB2 H. Y | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| PCB3 H. Y | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |

**Measurement- PCB Related**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Pin1 | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin2 | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin3 | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin1X | OK | Slightly NOK | OK | OK | OK | OK | Slightly NOK | Slightly NOK | Slightly NOK | OK |
| Pin2X | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin3X | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin1Y | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin2Y | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Pin3Y | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |

**Fig. 22.** PCB and Pin Measurement Result

### 3.3. Analyze Phase of the Study Project

After all these measurements and findings Ishikawa diagram was created with the team to find possible root causes for Suppression PCB failure. All causes are evaluated and possible effects are written as low, medium, and high. According to the Ishikawa diagram possible high causes are found in incorrect cover pin position or incorrect tool position and presented in Figure 23.

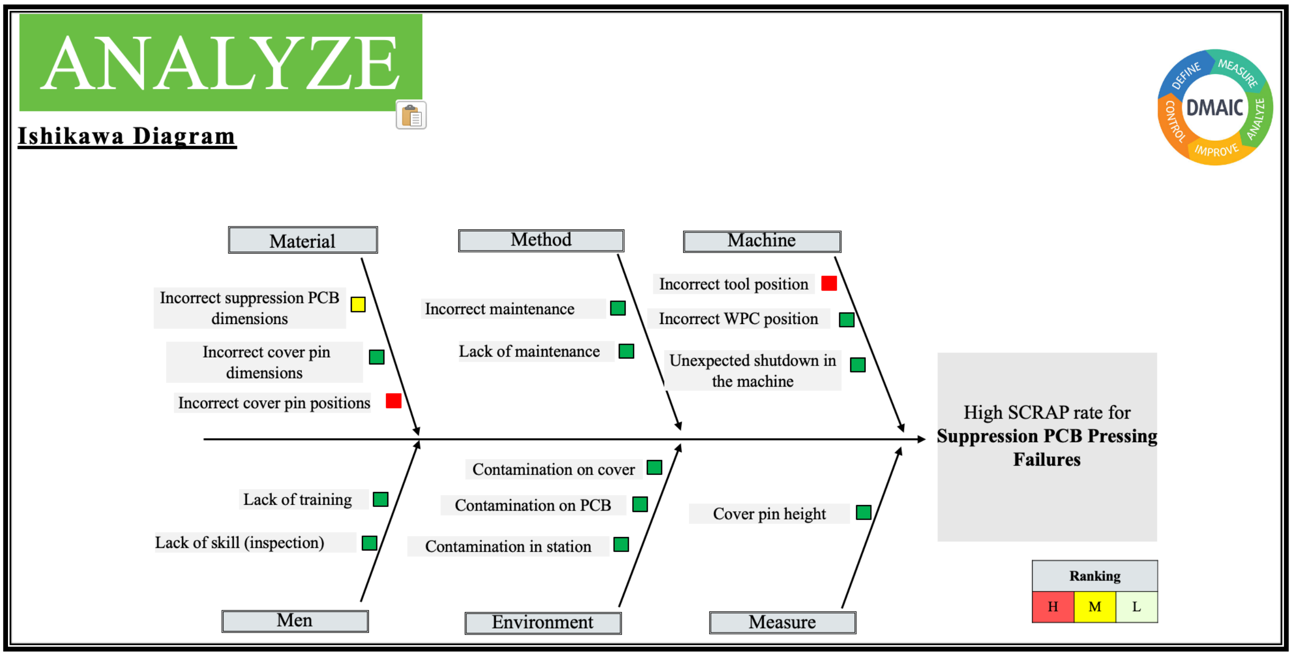



**Fig. 23.** Ishikawa Diagram for Suppression Failure

### 3.4. Improve and Control Phase of the Study Project

At this stage, each hypothesis was examined respectively. The first hypothesis that the incorrect cover pin position, so it was decided to first experiment with 5 pieces. For the trial, one pin from each of these 5 cover pieces was slightly bent, and then these pieces were processed manually. The purpose of this trial was to test whether the same curve could be obtained. When the curves created were checked, it was observed that the small peak that appeared at the very beginning of the process as it was given our problem was formed in the same way in this trial. Results are presented in Figure 24.

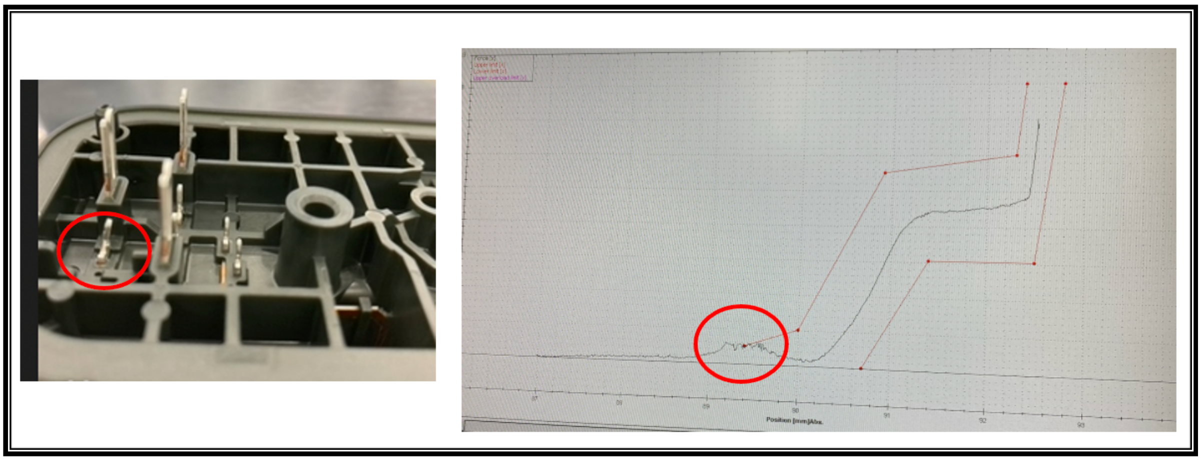


**Fig. 24.** Design of Experiment Result

Besides this another trial was done to check if the pin was bent too much instead of slightly what would be the pressing force curve. As seen in Figure 25 different graph was observed, due to the process not being performed as it should be done. Since the pin bent too much then even the pin is not going through into the PCB hole at all. Due to this at the beginning of the process, more force was applied than process limits during the pressing operation. This trial result shows that a bigger deviation on any cover pin causes a different curve than the under consideration problem.

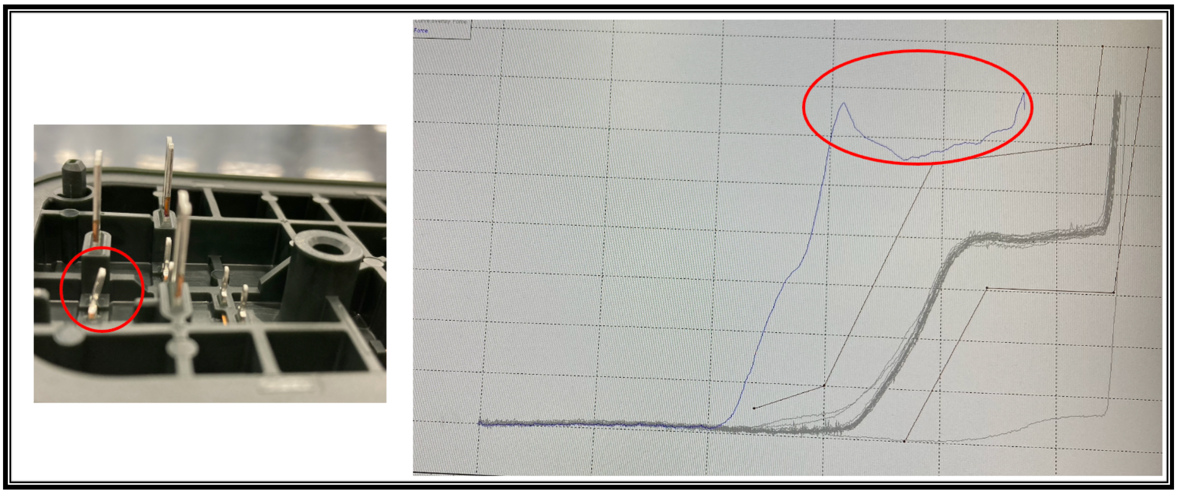


**Fig. 25.** Design of Experiment Result

In addition, in the cover pin position measurements, it was seen that 4 out of 10 covers were in an out-of-limit position, albeit slightly. In other words, evidence has been provided that the root cause is that the products sent by the supplier are slightly out of the limit. Although theoretically, the dimensions of the parts were outside the limits, there were two obstacles in practice in this study. The first obstacle may be caused by such small deviations due to measurement uncertainties or different device sensitivities. This causes a situation that requires a long time in the agreement with the supplier, but at the same time may cause the line to stop, and therefore the customer line to stop. And this is not desired because it is a painful process for both parties. The second obstacle is that this company is an international company, supplier agreements are made globally, and all plants are supplied with products of the same standards from the same suppliers. However, there are slight changes in the lines in different plants. This means that while such small differences do not affect production in some plants, they can cause serious production errors in others. In addition, these plants accept deviation approval in cases where small limit changes do not cause problems in the line and product, making it quite impossible for other plants in our situation to reach an agreement with the supplier and request improvements. Therefore, the best solution is to quickly adapt to such non-critical situations. For this reason, during the brainstorming session with the team, it was decided that such errors could be eliminated if position adjustments could be made to the tool. However, the existing tool did not allow such adjustments to be made. Therefore, it was decided to make changes to the tool design and use an adjustable tool. The second hypothesis is found as an incorrect tool position. Same as the first hypothesis 5 pieces part were taken for the trial. Then the tool position was shifted for trial and these parts were produced as usual. The same peak was seen at the curve as a solution ordering a new adjustable tool was decided by the DMAIC team. It can be seen in Figure 24.

# IMPROVE

**Subtitle**

| Cause Description | Solution description | Detailed description | Impact |
|---|---|---|---|
| Incorrect cover pin position | Adjustable tool | Suppliers may deliver slightly out-of-limit parts which is not critical for product safety or functionality. Due to coming over that kind of situation quickly, the tool position should be adjustable. PCB pressing surface which includes pins at the exact position should be movable. | High |
| Incorrect tool position | Adjustable tool | The tool position can be incorrect or shifted due to different reasons. Even if all pin positions are in limit, then still, all pins are shifted which causes that kind of pik at the beginning of the process. That's why to solve all these kinds of situations tool should be adjustable. | High |
| Incorrect suppression PBC hole dimensions | - | All PCB hole dimensions are in limit and OK position, even if not then a different type of curve occurs, and this hypothesis is not the case. | Low |

**Fig. 25.** Hypothesis and Solution

The design change was done on the tool drawing by internal process experts, and then it was ordered and delivered in 2 weeks. After that for the tool acceptance, the tool was implemented into the line, and 50 pcs parts were produced with a new tool after all adjustments. While waiting for the capability result line was not running with the new tool so switched to the old tool. When all measurements were done, and again short-term capability report was prepared, and found that the process was capable. Cpk value was found bigger than 1,67 as was expected, as seen in Figure 25.

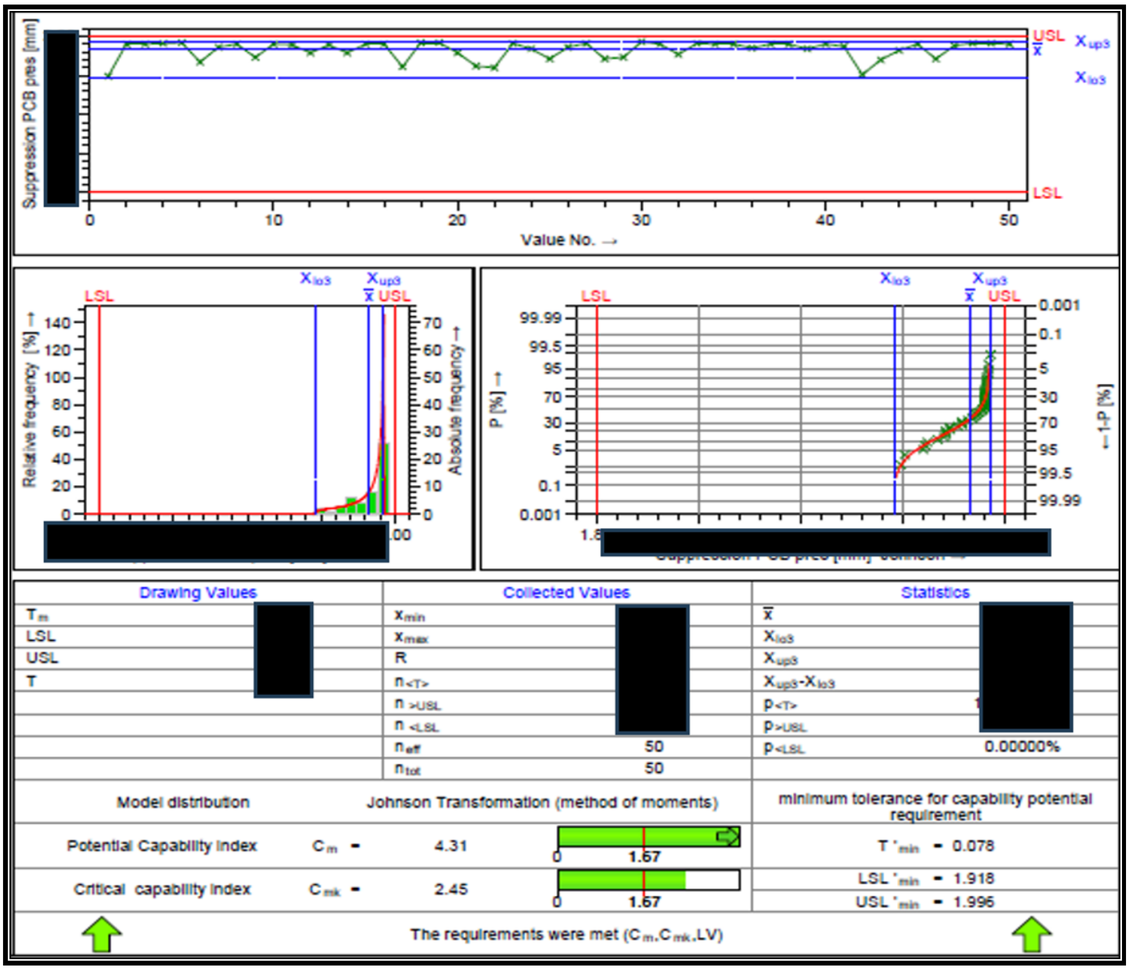



**Fig. 26.** Latest Short-term Capability Report

The last DMAIC step was the sustainability check. After the tool was accepted, the system was monitored from beginning of the November till to end, and the production amount and scrap amount produced for approximately 1 month were collected. According to this newly collected dataset, it was observed that the amount of production was 50232 pcs in this WGA line during this tracking time. And only 2 pcs Suppression PCB pressing failures were gotten. This result is better than the target value which was settled at the beginning of the project Define phase as 5 pcs/week. FYP was calculated for this station for 1 month as 99.99% which is the desired result.

### 3.5. Chapter of Summary

The chapter's main goal was to use the DMAIC technique to reduce Suppression PCB pressing scrap in Company "X"'s WGA assembly manufacturing line. The high scrap rate and its financial ramifications were the research problem. The Define, Measure, Analyze, Improve, and Control phases comprised the DMAIC framework, which served as the foundation for the study's fundamental design. A project team was assembled, and the project's scope, requirements, and clients were spelled out in detail during the Define phase. Capability measurements and MSA were used in the Measure phase to assess process performance and identify areas for improvement. Root causes are characterized by the identification of erroneous tool and cover pin positions during the Analyze phase. Testing hypotheses during the Improve phase resulted in the decision to modify the tool's design. The capacity to adapt a tool was enhanced by its implementation. Monitoring the system and maintaining enhancements were the main goals of the Control phase. The main conclusions showed that Suppression PCB pressing failures had significantly decreased, exceeding the original goal. The project's goals were successfully accomplished via the DMAIC technique, which is distinguished by a methodical approach and continuous improvement, improving process performance as well as financial advantages. The significance of organized problem-solving approaches in addressing production difficulties, enhancing product quality, and guaranteeing economic sustainability is highlighted by the research findings, which have great value for manufacturing organizations. The work adds to the body of knowledge on using DMAIC in practical industrial settings and offers guidance to researchers and practitioners looking for effective ways to address production-related problems.

## 4. Possible Financial Gain of the Proposed Solution

The primary goal of every manufacturing business is to turn a profit, which is a statistic that is closely linked to the cost of production. Establishing a competitive pricing strategy that guarantees economic sustainability requires striking the ideal balance between cost and product quality. In order to attain this delicate balance, it becomes necessary for the company to draw upon internal resources that support the improvement of production process effectiveness. Encouraging improvements in quality, general efficiency, and process optimization should be the primary focus of any strategic changes implemented within the manufacturing processes. As a result, these initiatives not only improve the company's goods' standing and market impression but also considerably boost profitability.

Opportunities to simplify quality control intervals arise when a manufacturing organization is resolute in its commitment to continual improvement. This phenomenon stems from the idea that process monitoring ongoing and stability enhancement eliminates the need for extensive quality inspection. The effectiveness of continuous improvement initiatives is demonstrated by the DMAIC project implemented by Company "X," as detailed in this extensive research. The reduction of Suppression PCB pressing scrap at the WGA line, which led to a significant improvement in process performance, was one of the project's particular goals.

The DMAIC framework allowed for a thorough analysis that demonstrated a high level of process control and efficiency. The concrete results of this project go beyond simple process improvement; as will be discussed in more detail in the next sections of this chapter. This strong commitment to ongoing improvement highlights the organization's proactive approach to responding to changing market conditions and demonstrates its commitment to excellence. Besides all this, this project was not providing only financial gain but also environmental gain. Since the failures continue, then 218 pcs PCB and plastic housing which is not possible to recycle or reuse due to commercial reasons would be wasted every 2 weeks. Wasting energy sources during these failures is also not preferable for the circular economy. Furthermore, by eliminating material waste and encouraging environmentally friendly production methods, lowering the scrap rate is consistent with sustainable manufacturing practices from an environmental standpoint.

### 4.1. Financial Gain Calculation for the Proposed Solution

It is essential to first identify the direct and indirect expenses associated with this failure during the project's cost calculation phase. Although the most important cost item is component costs which was presented at Table 3.

**Table 3.** Cost Analyses for Component

| Cost Reason | Cost (per pcs) | Amount | Total Cost (for 2 weeks-Eur) |
|---|---|---|---|
| Component- Cover | 1,1* | 218 | 239,8 |
| Component- PCB | 1,5* | 218 | 327 |
| Total | | | ≅567 |

**This price amount is reported according to general component prices; the exact company component price was not taken due to commercial confidentiality.*

It has been observed that there are also other non-direct costs. One of them, all parts that split to the Suppression station on the manufacturing line are taken away from the line due to the fact that have been classified as Non-OK (NOK), with rework being impossible, so are included in the cost computation. In accordance with the business quality process, the NOK components that are ejected from the line are also submitted to the laboratory for analysis. As a result, the appropriate laboratory analyst must spend time reporting and making the required measurements; this time expense is accounted for in the cost calculations as an indirect cost. In addition, once the laboratory analyst reports, the quality supervisor accounts for the time spent on error analysis. The time the laboratory specialist spent doing extra measurements for a thorough analysis is also included. This includes the time spent on measurement-related equipment, the energy costs associated with this equipment, the time the line technician spends transferring NOK parts for analysis, the cycle time loss the line experiences during producing NOK parts, downtime from a series of errors that cause the line to stop, and the time maintenance or process experts spend on tasks that indirectly affect costs. For all these components, a basic assumption is made regarding their costs. In the worst-case situation, expenses might occur from not being able to create enough goods in a timely manner to fulfill consumer demands, which could lead to production that is profitable or even penalty charges from line stoppages. In addition, additional effort needed to satisfy requests may result in staff and other expenses. However, since the manageable number of failures is taken into consideration, it is determined not to include these in the research. The suggested solution, however, includes changing the design of the tool internally. This entails paying for expert working hours, tool fees, line downtime for tool installation, and, lastly, the expert working hours in the laboratory needed to perform the acceptance capability test measurements. Assumptions regarding the energy consumption of the measuring equipment are also included. All the above-mentioned costs are placed in Table 4. Calculation is done based on 2 weeks.

**Table 4.** Analysis and Indirect Cost

| Cost Reason | Cost (per/hour) | Duration (hours) | Total Cost (for 2 weeks-Eur) |
|---|---|---|---|
| Analyses Cost | 30 | 1 | 30 |
| Lab- Specialist hour cost | 50 | 2 | 100 |
| Quality- Specialist hour cost | 50 | 2 | 100 |
| Other Estimated indirect cost | 200 | total | 200 |
| Total | | | **430** |

In order to conduct a feasibility analysis, the tool price and the one-time costs required to implement this tool on the line were also calculated and placed in Table 5.

**Table 5.** Cost Analyses for Solution and Comparison

| Cost Reason | Cost | Unit |
|---|---|---|
| Tool Price | 2000 | Euro |
| Quality- Specialist hour cost | 200 | Euro per hour |
| Other Estimated indirect cost | 100 | Euro |
| Total Solution Cost | **2300** | Euro |

The scrap amount was reduced dramatically which was from 218 to 5 as stated in the table above after the tool update implementation. The tooling investment is only for 2300 Euro to reduce the scrap cost from 997 Euro to 3.3 Euro (the initial target was 5 pcs of scrap for one week, but 3 pcs of scrap recorder for one month of production) by spending 2300 Euro as tool investment cost. Due to the recorded results, the tool has 4.6 weeks of payback time. For all these reasons, the project solution was found feasible for the implementation.

### 4.2. Chapter Summary

The objective of this investigation was to tackle the research issue of diminishing Suppression PCB pressing waste in the WGA assembly line at Company "X." Using the DMAIC methodology, the research concentrated on the overarching goal of improving process performance and generating financial advantages via initiatives for continuous improvement. The study's fundamental design comprised a thorough examination of the manufacturing process using instruments including the Ishikawa diagram, process maps, capability measures, project charter, SIPOC, and MSA. The main conclusions showed that applying the suggested approach significantly reduced the amount of Suppression PCB pressing scrap, which went from 218 pieces in 2 weeks to only 2 pieces in 1 month. The financial gain estimate showed that the tool cost for the solution would be repaid in 4.6 weeks by accounting for both direct and indirect expenditures related to the failure. A thorough evaluation of component costs, analytical expenses, and indirect costs supported this financial sustainability. According to the study's findings, the initiative not only met its financial objectives but also made a material waste reduction contribution to environmental sustainability. The interpretations demonstrate how well programs for continuous improvement may increase process control and efficiency. Finally, the DMAIC project at Company "X" highlights the importance of findings for both financial and environmental considerations in the context of automated assembly production and offers insightful information about reducing manufacturing scrap.

## Conclusions

This study focused on the development of the Wastegate Actuator assembly production process by DMAIC quality improvement approach. The DMAIC technique was methodically used to enable a more systematic and cohesive analysis, which helped to ensure that the study's stated objectives were completed quickly and effectively. The conclusions that follow are reached:

1. An essential part that controls the turbocharger valve and affects boost pressure and engine torque is the wastegate actuator. The engine's total efficiency and power output are directly impacted by the accuracy and dependability of the assembling process. The Wastegate Actuator assembly production process is a technological and complex manufacturing process due to fulfilling customer requirements not only at each station but also during the whole process. Company X uses advanced technology in its WGA assembly production line, using an Automated Mounting System for mass production. The line comprises nine modules, with Automated Optical Inspection checkpoints and camera and laser sensor systems for compliance.
2. Several statistical tools and techniques were applied methodically throughout the DMAIC phases. A comprehensive evaluation of the scrap rate is made possible by statistical analysis, which also aids in spotting trends, patterns, and possible sources of defects. By identifying fault-prone locations in the assembly process, statistical analysis enables manufacturers to cut costs and execute remedial actions. The efficacy and efficiency of the assembly process may be determined by analyzing the scrap rate. Processes may be made more efficient and productive overall by concentrating optimization efforts on the stages or components that have the highest frequency of faults.
3. Suppression PCB pressing failures in the WGA assembly process were effectively discovered, rectified, and minimized by using the DMAIC technique methodically through each phase. The analysis phase involved creating an Ishikawa diagram with the project team to identify possible root causes of Suppression PCB failures, resulting in high potential causes such as incorrect cover pin location or tool location. As a solution, it was suggested to change the tool design and switch to an adjustable tool. During the project's define phase, the goal was to reduce the amount of 218 scraps produced in a two-week period to a weekly target of 5 pieces. The executed solution, astonishingly, not only met but surpassed expectations, resulting in the generation of just 2 scraps in a month, and producing an excellent result.
4. The results of the financial analysis indicated that the costs related to the newly created tool which was suggested as the solution method would be recouped in 4.6 weeks. As a result, the project proved financially feasible because the feasibility assessment showed that the tool cost would be quickly recovered. This proves that investing in the suggested solution is highly justified given the predicted cost savings and efficiency gains.

## List of References


1. BASTOS, N.M., et al. Reconfiguration of Assembly Lines using Lean Thinking in an Electronics Components' Manufacturer for the Automotive Industry. *Procedia Manufacturing*, 2021, vol. 55. pp. 383-392. Available from: https://www.sciencedirect.com/science/article/pii/S235197892100250X ISSN 2351-9789. DOI 10.1016/j.promfg.2021.10.053.
2. SILVA, F.J.G., et al. Analysis and Development of a Failure Prediction Model for Electrical Terminals used in the Automotive Industry. *Procedia Manufacturing*, 2020, vol. 51. pp. 207-214. Available from: https://www.sciencedirect.com/science/article/pii/S2351978920318850 ISSN 2351-9789. DOI 10.1016/j.promfg.2020.10.030.
3. RODRIGUES, H., et al. A Novel Computer Application for Scrap Reporting and Data Management in the Manufacturing of Components for the Automotive Industry. *Procedia Manufacturing*, 2020, vol. 51. pp. 1319-1326. Available from: https://www.sciencedirect.com/science/article/pii/S2351978920320412 ISSN 2351-9789. DOI 10.1016/j.promfg.2020.10.184.
4. MITTAL, A., et al. The Performance Improvement Analysis using Six Sigma DMAIC Methodology: A Case Study on Indian Manufacturing Company. *Heliyon*, 2023, vol. 9, no. 3. pp. e14625. Available from: https://www.sciencedirect.com/science/article/pii/S2405844023018327 ISSN 2405-8440. DOI 10.1016/j.heliyon.2023.e14625.
5. *DMAIC Process & Methodology: An Essential Guide.* -04-23T05:00:00+00:00, 2020 [viewed Nov 26, 2023]. Available from:https://www.juran.com/blog/dmaic-attaining-superior-quality-sustainable-results/.
6. CARROLL, C.T. *Six Sigma for Powerful Improvement a Green Belt DMAIC Training System with Software Tools and a 25-Lesson Course.* Boca Raton Fla.]: CRC/Taylor & Francis, 2013 ISBN 9781466564695.
7. SOKOVIC, M., et al. *Quality Improvement Methodologies -PDCA Cycle, RADAR Matrix, DMAIC and DFSS.* , 2010.
8. VELKOSKA, C. and TOMOV, M. Understanding and Application Of quality Costs in Automotive Manufacturing Companies in North Macedonia: Empirical Study. *The International Journal of Quality & Reliability Management*, May 23, 2023, vol. 40, no. 6. pp. 1463-1484. Available from: https://www.emerald.com/insight/content/doi/10.1108/IJQRM-01-2022-0032/full/html CrossRef. ISSN 0265-671X. DOI 10.1108/IJQRM-01-2022-0032.
9. FAROOQ, M.A., KIRCHAIN, R., NOVOA, H. and ARAUJO, A. Cost of Quality: Evaluating Cost-Quality Trade-Offs for Inspection Strategies of Manufacturing Processes. *International Journal of Production Economics*, 2017, vol. 188. pp. 156-166. Available from: https://www-sciencedirect-com.ezproxy.ktu.edu/science/article/pii/S0925527317301135 ISSN 0925-5273. DOI 10.1016/j.ijpe.2017.03.019.
10. HOYLE, D. *Automotive Quality Systems Handbook.* 2; 2nd ed. ed. San Diego: San Diego: Elsevier Science, 2005 ISBN 9780080458502; 0080458505; 9780750666633; 0750666633.
11. JMMP | Free Full-Text | Virtual Quality Gates in Manufacturing Systems: Framework, Implementation and Potential [viewed Dec 5, 2023]. Available from: https://www.mdpi.com/2504-4494/4/4/106.
12. MONTGOMERY DOUGLAS C. *Introduction to Statistical Quality Control.* 6th ed. [viewed Nov 26, 2023]. Available from: https://www.uaar.edu.pk/fs/books/12.pdf.

13. BOZZA, F., BELLIS, V.D., TEODOSIO, L. and GIMELLI, A. Numerical Analysis of the Transient Operation of a Turbocharged Diesel Engine Including the Compressor Surge. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, 2013, vol. 227, no. 11. pp. 1503-1517. Available from: https://doi-org.ezproxy.ktu.edu/10.1177/0954407013501668 ISSN 0954-4070. DOI 10.1177/0954407013501668.
14. THOMASSON, A., ERIKSSON, L., LEUFVÉN, O. and ANDERSSON, P. Wastegate Actuator Modeling and Model-Based Boost Pressure Control. *IFAC Proceedings Volumes*, 2009, vol. 42, no. 26. pp. 87-94. Available from: https://www-sciencedirect-com.ezproxy.ktu.edu/science/article/pii/S1474667016337351 ISSN 1474-6670. DOI 10.3182/20091130-3-FR-4008.00012.
15. HOLMBOM, R. and LIANG, B. *Boost Control with Turbo Speed Sensor and Electric Wastegate.* Linköpings universitet, Fordonssystem, Jan 01, 2016 Available from: https://explore.openaire.eu/search/publication?articleId=od_______261::5cb75682eec360128b087d2eabc850bd.
16. BAEK, S. *Development of Electric Waste Gate Actuator using Planetary Gear and DC Motor for Turbocharger.* , 2022.
17. EMEKLI, M.E. *Design of an Intelligent Boost Pressure Controller for a Series Sequential Turbocharged Diesel Engine.* Đstanbul Technical University, 2015 DOI 10.26686/wgtn.24276763.
18. *ELECTRONIC BOOST PRESSURE CONTROL- TURBOCHARGER ACTUATOR TESTING| Faurecia.* [viewed Oct 28, 2023]. Available from:https://www.hella.com/techworld/uk/Technical/Car-electronics-and-electrics/Electronic-boost-pressure-control-turbocharger-actuator-testing-61101/.
19. PUGNA, A., POTRA, S., NEGREA, R. and MICLEA, S. *Applying Six Sigma Methodology in the Automotive Industry.* Springer, Cham, 2020 [viewed Nov 19, 2023]. Available from: https://link-springer-com.ezproxy.ktu.edu/chapter/10.1007/978-3-030-44711-3_49 ISBN 2198-7254. DOI 10.1007/978-3-030-44711-3_49.
20. COHEN, L. *Quality Function Deployment: How to make QFD Work for You.* Reading Mass.]: Addison-Wesley, 1995 ISBN 0201633302.
21. *Systems Modeling for Business Process Improvement.* Boston Mass.]: Artech House, 2000 ISBN 1580530508.
22. ABDUL HALIM LIM, S., ANTONY, J., HE, Z. and ARSHED, N. Critical Observations on the Statistical Process Control Implementation in the UK Food Industry: A Survey. *The International Journal of Quality & Reliability Management*, 2017, vol. 34, no. 5. pp. 684-700 ISSN 0265-671X. DOI 10.1108/IJQRM-03-2015-0035.
23. GODINA, R., MATIAS, J. and AZEVEDO, S. Quality Improvement with Statistical Process Control in the Automotive Industry. *International Journal of Industrial Engineering and Management*, -02-20, 2016, vol. 7 [viewed Nov 26, 2023]. pp. 1-8 DOI 10.24867/IJIEM-2016-1-101.
24. Mahesj Chinnagiri. *Computer Implemented Method and System for Monitoring Quality in Product and/Or Service Associated Projects by Application of Improvement in Six Sigma Methodology.* , 2010.
25. Gary L. Henby and S. Mark Joyner. *Methods and System for Production of Products.* , 2009.

26. WOODALL, W.H. *Introduction to Statistical Process Control.* Milwaukee: Milwaukee: Taylor & Francis, 2014 ISBN 0022-4065. DOI 10.1080/00224065.2014.11917963.
27. Press Fit Technology Roadmap and Control Parameters for a High Performance Process [viewed Nov 18, 2023]. Available from: https://www.circuitinsight.com/pdf/press_fit_technology_roadmap_control_parameters_ipc.pdf.
28. *Mounting Guideline for F1 / F2 Modules with Press-Fit.* [viewed Nov 18, 2023]. Available from: https://www.onsemi.com/pub/Collateral/AN-4167-D.PDF.
29. TRIMARJOKO, A., HARDI PURBA, H. and NINDIANI, A. Consistency of DMAIC Phases Implementation on Six Sigma Method in Manufacturingand Service Industry: A Literature Review. *Management and Production Engineering Review*, Oct 01, 2020, vol. 11, no. 4. Available from: https://search.proquest.com/docview/2651861055 Publicly Available Content Database. ISSN 2080-8208. DOI 10.24425/mper.2020.136118.
30. *The Improve Phase of DMAIC Process: Making Change that Lasts.* Available from:https://www.sixsigmaonline.org/dmaic-improve-phase/.

# Appendices

## Appendix 1. CW31-CW32 Dataset

| No | DMC | Last Station | Status | Date | Line |
|---|---|---|---|---|---|
| 3313 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/11/2023 | WGA |
| 3314 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/11/2023 | WGA |
| 3315 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/11/2023 | WGA |
| 3316 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3317 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3318 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3319 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3320 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3321 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3322 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3323 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3324 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3325 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3326 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3327 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3328 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3329 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3330 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3331 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3332 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3333 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3334 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3335 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3336 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3337 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3338 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3339 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3340 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3341 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3342 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3343 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3344 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3345 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3346 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3347 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3348 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3349 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3350 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3351 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3352 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3353 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3354 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3355 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/11/2023 | WGA |
| 3356 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/11/2023 | WGA |
| 3357 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/11/2023 | WGA |
| 3358 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/11/2023 | WGA |
| 3359 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/11/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 3360 | 1.452E+13 | SCADA Booking | Fail | 8/11/2023 | WGA |
| 3361 | 1.452E+13 | SCADA Booking | Fail | 8/11/2023 | WGA |
| 3362 | 1.452E+13 | SCADA Booking | Fail | 8/11/2023 | WGA |
| 3363 | 1.452E+13 | SCADA Booking | Fail | 8/11/2023 | WGA |
| 3364 | 1.452E+13 | SCADA Booking | Fail | 8/11/2023 | WGA |
| 3365 | 1.452E+13 | SCADA Booking | Fail | 8/11/2023 | WGA |
| 3366 | 1.452E+13 | Scrap in Line | Fail | 8/11/2023 | WGA |
| 3367 | 1.452E+13 | Scrap in Line | Fail | 8/11/2023 | WGA |
| 3368 | 1.452E+13 | Scrap in Line | Fail | 8/11/2023 | WGA |
| 3369 | 1.452E+13 | Scrap in Line | Fail | 8/11/2023 | WGA |
| 3370 | 1.452E+13 | Scrap in Line | Fail | 8/11/2023 | WGA |
| 4019 | 1.452E+13 | ITAC Booking | Fail | 8/10/2023 | WGA |
| 6477 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/10/2023 | WGA |
| 6478 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/10/2023 | WGA |
| 6479 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6480 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6481 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6482 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6483 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6484 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6485 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6486 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6487 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6488 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6489 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6490 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6491 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6492 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6493 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6494 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6495 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6496 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6497 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6498 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/10/2023 | WGA |
| 6499 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/10/2023 | WGA |
| 6500 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/10/2023 | WGA |
| 6501 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6502 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6503 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6504 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6505 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6506 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6507 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/10/2023 | WGA |
| 6508 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/10/2023 | WGA |
| 6509 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/10/2023 | WGA |
| 6510 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/10/2023 | WGA |
| 6511 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/10/2023 | WGA |
| 6512 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/10/2023 | WGA |
| 6513 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6514 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6515 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6516 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6517 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 6518 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6519 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6520 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6521 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6522 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6523 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6524 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6525 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6526 | 1.452E+13 | SCADA Booking | Fail | 8/10/2023 | WGA |
| 6527 | 1.452E+13 | Scrap in Line | Fail | 8/10/2023 | WGA |
| 6528 | 1.452E+13 | Scrap in Line | Fail | 8/10/2023 | WGA |
| 6529 | 1.452E+13 | Scrap in Line | Fail | 8/10/2023 | WGA |
| 6530 | 1.452E+13 | ITAC Booking | Fail | 8/10/2023 | WGA |
| 10523 | 1.452E+13 | 08 Screw the PCB into HG Mod 40.3 | Fail | 8/9/2023 | WGA |
| 10524 | 1.452E+13 | 08 Screw the PCB into HG Mod 40.3 | Fail | 8/9/2023 | WGA |
| 10525 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/9/2023 | WGA |
| 10526 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/9/2023 | WGA |
| 10527 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/9/2023 | WGA |
| 10528 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/9/2023 | WGA |
| 10529 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10530 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10531 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10532 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10533 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10534 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10535 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10536 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10537 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10538 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/9/2023 | WGA |
| 10539 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/9/2023 | WGA |
| 10540 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/9/2023 | WGA |
| 10541 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/9/2023 | WGA |
| 10542 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/9/2023 | WGA |
| 10543 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/9/2023 | WGA |
| 10544 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10545 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10546 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10547 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10548 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10549 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10550 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10551 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10552 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/9/2023 | WGA |
| 10553 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/9/2023 | WGA |
| 10554 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/9/2023 | WGA |
| 10555 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/9/2023 | WGA |
| 10556 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/9/2023 | WGA |
| 10557 | 1.452E+13 | Scrap in Line | Fail | 8/9/2023 | WGA |
| 10558 | 1.452E+13 | Scrap in Line | Fail | 8/9/2023 | WGA |
| 10559 | 1.452E+13 | ITAC Booking | Fail | 8/9/2023 | WGA |
| 10560 | 1.452E+13 | ITAC Booking | Fail | 8/9/2023 | WGA |
| 15253 | 1.452E+13 | 08 Screw the PCB into HG Mod 40.3 | Fail | 8/8/2023 | WGA |
| 15254 | 1.452E+13 | 08 Screw the PCB into HG Mod 40.3 | Fail | 8/8/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 15255 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/8/2023 | WGA |
| 15256 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/8/2023 | WGA |
| 15257 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/8/2023 | WGA |
| 15258 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/8/2023 | WGA |
| 15259 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/8/2023 | WGA |
| 15260 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/8/2023 | WGA |
| 15261 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/8/2023 | WGA |
| 15262 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/8/2023 | WGA |
| 15263 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/8/2023 | WGA |
| 15264 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/8/2023 | WGA |
| 15265 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/8/2023 | WGA |
| 15266 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/8/2023 | WGA |
| 15267 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/8/2023 | WGA |
| 15268 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15269 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15270 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15271 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15272 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15273 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15274 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15275 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15276 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15277 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15278 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15279 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15280 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15281 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15282 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/8/2023 | WGA |
| 15283 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/8/2023 | WGA |
| 15284 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/8/2023 | WGA |
| 15285 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/8/2023 | WGA |
| 15286 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/8/2023 | WGA |
| 15287 | 1.452E+13 | SCADA Booking | Fail | 8/8/2023 | WGA |
| 15288 | 1.452E+13 | SCADA Booking | Fail | 8/8/2023 | WGA |
| 15289 | 1.452E+13 | SCADA Booking | Fail | 8/8/2023 | WGA |
| 15290 | 1.452E+13 | SCADA Booking | Fail | 8/8/2023 | WGA |
| 15291 | 1.452E+13 | SCADA Booking | Fail | 8/8/2023 | WGA |
| 15292 | 1.452E+13 | SCADA Booking | Fail | 8/8/2023 | WGA |
| 15293 | 1.452E+13 | Scrap in Line | Fail | 8/8/2023 | WGA |
| 15294 | 1.452E+13 | Scrap in Line | Fail | 8/8/2023 | WGA |
| 15295 | 1.452E+13 | Scrap in Line | Fail | 8/8/2023 | WGA |
| 15720 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/7/2023 | WGA |
| 15721 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15722 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15723 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15724 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15725 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15726 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15727 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15728 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15729 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15730 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15731 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 15732 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15733 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15734 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15735 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15736 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15737 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15738 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15739 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15740 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15741 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15742 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15743 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15744 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15745 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15746 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15747 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15748 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15749 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15750 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15751 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15752 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/7/2023 | WGA |
| 15753 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/7/2023 | WGA |
| 15754 | 1.452E+13 | 08 Screw the PCB into HG Mod 40.3 | Fail | 8/7/2023 | WGA |
| 15755 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/7/2023 | WGA |
| 15756 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/7/2023 | WGA |
| 15757 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15758 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15759 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15760 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15761 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15762 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15763 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15764 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/7/2023 | WGA |
| 15765 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/7/2023 | WGA |
| 15766 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/7/2023 | WGA |
| 15767 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/7/2023 | WGA |
| 15768 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/7/2023 | WGA |
| 15769 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/7/2023 | WGA |
| 15770 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/7/2023 | WGA |
| 15771 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/7/2023 | WGA |
| 15772 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/7/2023 | WGA |
| 15773 | 1.452E+13 | 20 Station Laser Marking/NOK Mod 70.5 | Fail | 8/7/2023 | WGA |
| 15774 | 1.452E+13 | SCADA Booking | Fail | 8/7/2023 | WGA |
| 15775 | 1.452E+13 | SCADA Booking | Fail | 8/7/2023 | WGA |
| 15776 | 1.452E+13 | Scrap in Line | Fail | 8/7/2023 | WGA |
| 15777 | 1.452E+13 | Scrap in Line | Fail | 8/7/2023 | WGA |
| 15778 | 1.452E+13 | Scrap in Line | Fail | 8/7/2023 | WGA |
| 19971 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/4/2023 | WGA |
| 19972 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19973 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19974 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19975 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19976 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 19977 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19978 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19979 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19980 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19981 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19982 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/4/2023 | WGA |
| 19983 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/4/2023 | WGA |
| 19984 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/4/2023 | WGA |
| 19985 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/4/2023 | WGA |
| 19986 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19987 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19988 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19989 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19990 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19991 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19992 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/4/2023 | WGA |
| 19993 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/4/2023 | WGA |
| 19994 | 1.452E+13 | 20 Station Laser Marking/NOK Mod 70.5 | Fail | 8/4/2023 | WGA |
| 19995 | 1.452E+13 | 20 Station Laser Marking/NOK Mod 70.5 | Fail | 8/4/2023 | WGA |
| 23212 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/3/2023 | WGA |
| 23213 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/3/2023 | WGA |
| 23214 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23215 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23216 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23217 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23218 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23219 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23220 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23221 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23222 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23223 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23224 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23225 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23226 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23227 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23228 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23229 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23230 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23231 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23232 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23233 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23234 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23235 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23236 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/3/2023 | WGA |
| 23237 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23238 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23239 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23240 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23241 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23242 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23243 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23244 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23245 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |

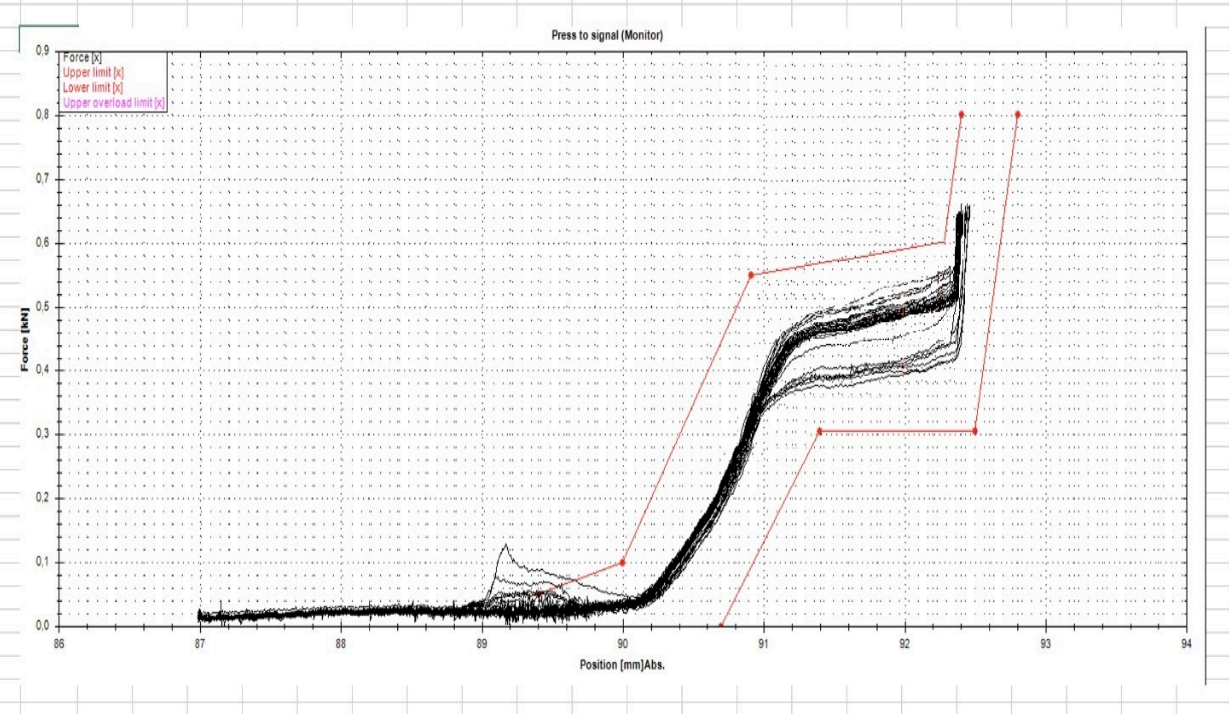
| | | | | | |
|---|---|---|---|---|---|
| 23246 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23247 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23248 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23249 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23250 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23251 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23252 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/3/2023 | WGA |
| 23253 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/3/2023 | WGA |
| 23254 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/3/2023 | WGA |
| 23255 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 8/3/2023 | WGA |
| 23256 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/3/2023 | WGA |
| 23257 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/3/2023 | WGA |
| 23258 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/3/2023 | WGA |
| 23259 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/3/2023 | WGA |
| 23260 | 1.452E+13 | SCADA Booking | Fail | 8/3/2023 | WGA |
| 23261 | 1.452E+13 | SCADA Booking | Fail | 8/3/2023 | WGA |
| 23262 | 1.452E+13 | SCADA Booking | Fail | 8/3/2023 | WGA |
| 23263 | 1.452E+13 | Dropped | Fail | 8/3/2023 | WGA |
| 24968 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/2/2023 | WGA |
| 24969 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/2/2023 | WGA |
| 24970 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/2/2023 | WGA |
| 24971 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/2/2023 | WGA |
| 24972 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/2/2023 | WGA |
| 24973 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/2/2023 | WGA |
| 24974 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24975 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24976 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24977 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24978 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24979 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24980 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24981 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24982 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24983 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24984 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24985 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24986 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24987 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24988 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24989 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24990 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24991 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24992 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24993 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24994 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24995 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24996 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24997 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24998 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 24999 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 25000 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 25001 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 25002 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 25003 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/2/2023 | WGA |
| 25004 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/2/2023 | WGA |
| 25005 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 8/2/2023 | WGA |
| 25006 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/2/2023 | WGA |
| 25007 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/2/2023 | WGA |
| 25008 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 8/2/2023 | WGA |
| 25009 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 8/2/2023 | WGA |
| 25010 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/2/2023 | WGA |
| 25011 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/2/2023 | WGA |
| 25012 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/2/2023 | WGA |
| 25013 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/2/2023 | WGA |
| 25014 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/2/2023 | WGA |
| 25015 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25016 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25017 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25018 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25019 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25020 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25021 | 1.452E+13 | SCADA Booking | Fail | 8/2/2023 | WGA |
| 25022 | 1.452E+13 | Scrap in Line | Fail | 8/2/2023 | WGA |
| 31071 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31072 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31073 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31074 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31075 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31076 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31077 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 8/1/2023 | WGA |
| 31078 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 8/1/2023 | WGA |
| 31079 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31080 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31081 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31082 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31083 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31084 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31085 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31086 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31087 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31088 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31089 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31090 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31091 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31092 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31093 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31094 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31095 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31096 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31097 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31098 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31099 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31100 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31101 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31102 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31103 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 31104 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31105 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31106 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31107 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31108 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31109 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31110 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31111 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31112 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 8/1/2023 | WGA |
| 31113 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 8/1/2023 | WGA |
| 31114 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31115 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31116 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31117 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31118 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31119 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31120 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31121 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 8/1/2023 | WGA |
| 31122 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 8/1/2023 | WGA |
| 31123 | 1.452E+13 | SCADA Booking | Fail | 8/1/2023 | WGA |
| 31124 | 1.452E+13 | SCADA Booking | Fail | 8/1/2023 | WGA |
| 31125 | 1.452E+13 | SCADA Booking | Fail | 8/1/2023 | WGA |
| 31126 | 1.452E+13 | SCADA Booking | Fail | 8/1/2023 | WGA |
| 31127 | 1.452E+13 | SCADA Booking | Fail | 8/1/2023 | WGA |
| 31128 | 1.452E+13 | SCADA Booking | Fail | 8/1/2023 | WGA |
| 31129 | 1.452E+13 | Dropped | Fail | 8/1/2023 | WGA |
| 31130 | 1.452E+13 | Dropped | Fail | 8/1/2023 | WGA |
| 37491 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37492 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37493 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37494 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37495 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37496 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37497 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37498 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37499 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37500 | 1.452E+13 | 03 Axles Pressing Mod 20.1 | Fail | 7/31/2023 | WGA |
| 37501 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 7/31/2023 | WGA |
| 37502 | 1.452E+13 | 05 Screw of the Fix Element Mod 20.4 | Fail | 7/31/2023 | WGA |
| 37503 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37504 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37505 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37506 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37507 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37508 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37509 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37510 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37511 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37512 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37513 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37514 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37515 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37516 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |

| | | | | | |
|---|---|---|---|---|---|
| 37517 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37518 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37519 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37520 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37521 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37522 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37523 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37524 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37525 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37526 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37527 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37528 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37529 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37530 | 1.452E+13 | 06 Suppression PCB Pressing Mod 40.1 | Fail | 7/31/2023 | WGA |
| 37531 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 7/31/2023 | WGA |
| 37532 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 7/31/2023 | WGA |
| 37533 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 7/31/2023 | WGA |
| 37534 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 7/31/2023 | WGA |
| 37535 | 1.452E+13 | 07 Sensor PCB Pressing Mod 40.2 | Fail | 7/31/2023 | WGA |
| 37536 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 7/31/2023 | WGA |
| 37537 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 7/31/2023 | WGA |
| 37538 | 1.452E+13 | 14 Connecting Element Pressing Mod 60.1 | Fail | 7/31/2023 | WGA |
| 37539 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 7/31/2023 | WGA |
| 37540 | 1.452E+13 | 15 Output Cover Laser Welding Mod 60.2 | Fail | 7/31/2023 | WGA |
| 37541 | 1.452E+13 | 16 EOL 1 Mod 70 | Fail | 7/31/2023 | WGA |
| 37542 | 1.452E+13 | 17 EOL 2 Mod 70 | Fail | 7/31/2023 | WGA |
| 37543 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37544 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37545 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37546 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37547 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37548 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37549 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37550 | 1.452E+13 | 18 EOL 3 Mod 70 | Fail | 7/31/2023 | WGA |
| 37551 | 1.452E+13 | 19 EOL 4 Mod 70 | Fail | 7/31/2023 | WGA |
| 37552 | 1.452E+13 | SCADA Booking | Fail | 7/31/2023 | WGA |
| 37553 | 1.452E+13 | SCADA Booking | Fail | 7/31/2023 | WGA |
| 37554 | 1.452E+13 | Scrap in Line | Fail | 7/31/2023 | WGA |
| 37555 | 1.452E+13 | Intervention in Line | Fail | 7/31/2023 | WGA |

## Appendix 2. Produced parts Pressing Curve




## Appendix 3. Pin Height for the Short-Term Capability Report

| | PCB small pressing (1.8/2.0) |
|---|---|
| 1 | 1,949 |
| 2 | 1,997 |
| 3 | 1,99 |
| 4 | 1,996 |
| 5 | 1,992 |
| 6 | 1,967 |
| 7 | 1,986 |
| 8 | 1,993 |
| 9 | 1,973 |
| 10 | 1,995 |
| 11 | 1,989 |
| 12 | 1,979 |
| 13 | 1,996 |
| 14 | 1,979 |
| 15 | 1,996 |
| 16 | 1,994 |
| 17 | 1,961 |
| 18 | 1,992 |
| 19 | 1,992 |
| 20 | 1,979 |
| 21 | 1,962 |
| 22 | 1,96 |
| 23 | 1,991 |
| 24 | 1,984 |
| 25 | 1,971 |

| | |
|---|---|
| 26 | 1,986 |
| 27 | 1,991 |
| 28 | 1,971 |
| 29 | 1,973 |
| 30 | 1,993 |
| 31 | 1,996 |
| 32 | 1,977 |
| 33 | 1,994 |
| 34 | 1,997 |
| 35 | 1,996 |
| 36 | 1,985 |
| 37 | 1,996 |
| 38 | 1,996 |
| 39 | 1,984 |
| 40 | 1,99 |
| 41 | 1,987 |
| 42 | 1,951 |
| 43 | 1,97 |
| 44 | 1,982 |
| 45 | 1,996 |
| 46 | 1,971 |
| 47 | 1,988 |
| 48 | 1,994 |
| 49 | 1,991 |
| 50 | 1,996 |

## Appendix 4. Pin Present Check Value for MSA Report

| Attributive MSA, Pin present Check | | | |
|---|---|---|---|
| No. | Part placed | Value received | Passed |
| 1 | OK | OK | |
| 2 | NOK | NOK | |
| 3 | OK | OK | |
| 4 | NOK | NOK | |
| 5 | OK | OK | |
| 6 | NOK | NOK | |
| 7 | OK | OK | |
| 8 | NOK | NOK | |
| 9 | OK | OK | |
| 10 | NOK | NOK | |
| 11 | OK | OK | |
| 12 | NOK | NOK | |
| 13 | OK | OK | |
| 14 | NOK | NOK | |
| 15 | OK | OK | |

| | | |
|---|---|---|
| 16 | NOK | NOK |
| 17 | OK | OK |
| 18 | NOK | NOK |
| 19 | OK | OK |
| 20 | NOK | NOK |
| 21 | OK | OK |
| 22 | NOK | NOK |
| 23 | OK | OK |
| 24 | NOK | NOK |
| 25 | OK | OK |
| 26 | NOK | NOK |
| 27 | OK | OK |
| 28 | NOK | NOK |
| 29 | OK | OK |
| 30 | NOK | NOK |
| 31 | OK | OK |
| 32 | NOK | NOK |
| 33 | OK | OK |
| 34 | NOK | NOK |
| 35 | OK | OK |
| 36 | NOK | NOK |
| 37 | OK | OK |
| 38 | NOK | NOK |
| 39 | OK | OK |
| 40 | NOK | NOK |