ANALYSIS AND COUNTERMEASURE TO IMPROVE OVERALL EQUIPMENT EFFECTIVENESS (OEE) ON CHASSIS LINE AT TAN CHONG INDUSTRY

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NUR SYAHIRAH BINTI ISMAIL

Thesis submitted in fulfilment of the requirements for the award of the degree of
B.Eng. (Hons.) Manufacturing Engineering

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

DEC 2016

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Manufacturing Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own expect for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Overall Equipment Effectiveness (OEE) is a powerful metric of manufacturing performance incorporating measures of the utilization, yield and efficiency of a given process, machine or manufacturing line. When associated with the reasons for performance loss, OEE provides the means to compare and priorities improvement efforts. This project assesses the current condition of Chassis-Final Assembly lines of Nissan Tan Chong Motor Assemblies Sdn Bhd, a company of car manufacturer in order to reduce unplanned downtime due to line stoppages to maximize the productivity. Before obtaining the data to calculate the existing OEE value, the product or process that have the highest downtime rate need to be identified at Chassis-Final Assembly Department. The methods used to analyze these various causes were control chart to find the out of control point, Pareto Analysis to find the critical problem, Ishikawa diagram to find causes affecting the problem, and 5W1H to proposed the recommendation. After knowing the causes of various activities that leads to high downtime rate, then recommendations for OEE improvements are 84.35% and 84.31% for A, and B shift respectively. From the existing to world class ranking OEE there are improved by 4.51% and 4.71% for A, and B shift respectively, that could be used by Nissan Tan Chong Motor Assemblies Sdn Bhd were ready to be made.

ABSTRAK

Keberkesanan keseluruhan Equipment (OEE) adalah metrik kuat pembuatan langkah-langkah prestasi pemerbadanan penggunaan, hasil dan kecekapan proses, mesin atau pembuatan garis diberikan. Apabila dikaitkan dengan sebab-sebab bagi kehilangan prestasi, OEE menyediakan cara-cara untuk membandingkan dan usaha keutamaan penambahbaikan. Projek ini menilai keadaan semasa garis Perhimpunan Chassis-Final Nissan Tan Chong Motor Assemblies Sdn Bhd, sebuah syarikat pengeluar kereta untuk mengurangkan tidak dirancang kerugian masa ke atas penamatan baris kerja untuk memaksimumkan produktiviti. Sebelum mendapatkan data untuk mengira nilai OEE yang sedia ada, produk atau proses yang mempunyai tertinggi menurunkan kadar masa perlu dikenal pasti di Chassis-Final Jabatan Perhimpunan. Kaedah yang digunakan untuk menganalisis pelbagai sebab adalah carta kawalan untuk mencari titik keluar dari kawalan, Analisis Pareto untuk mencari masalah yang kritikal, gambarajah Ishikawa untuk mengesan punca utama masalah, dan 5W1H untuk mengusulkan cadangan. Setelah mengetahui punca-punca pelbagai aktiviti yang membawa kepada kadar downtime tinggi, maka cadangan untuk penambahbaikan yang boleh digunakan oleh Nissan Tan Chong Motor Assemblies Sdn Bhd bersedia untuk dibuat.

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OEE	Overall Equipment Effectiveness
TPM	Total Productive Maintenance

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter discusses about the introduction, overall ideas and concepts to the Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE). Besides, the background of the study, problem statements, objective of the study, and scope of the study will also be described in details in the sections below.

1.2 BACKGROUND OF STUDY

In a competitive market, the growing demand for quality as the most important factor for a company to survive in the global market is growing. Quality is important in determining the economic success of manufacturing companies. Total Quality Management (TQM) is an approach to improve the quality of goods and services delivered through the involvement of individuals at all levels and functions of the organization. Quality management practices also help improve in reducing scrap, rework and stabilize the production process. Thus, can reduce production costs and increase productivity.

Tan Chong Motor Assemblies Sdn. Bhd. (TCMA) was selected to be studied in this research. It is one of the largest national conglomerates involved in a myriad of business activities. The current activities of the Tan Chong Motor Assemblies Sdn. Bhd. (TCMA) are assembly and distribution of motor vehicles, provision after-sales services and motor related financial services.

This study is conducted by choosing the Assembly Shop Chassis line as a research. Assembly Chassis line has 2 shifts with 7.9 hours per shift, which means the total operation per shift is 474 minutes-based. They explained that they are facing a high probability of loss of production lines for machine damage stoppage.

Through the first visit to the company in accordance Assembly Shop Chassis line, the operator were observed that they could not read the air leak tester due to failure of reading and Chassis-Final conveyor cannot running very well. In addition, the chassis assembly line downtime loss is 10 to 20 minutes by the time available of 474 minutes per shift, therefore, the operating time was decrease to 4.22 per cent, and this is due to equipment failure affected from waiting and no raw materials. Downtime losses was reflected to low availability. The number of units produced is 50 units out of total potential targets of 60 units in every shift. So that, it shown that the performance is low by 83.3 percent. This is due to minor stoppage due to speed loss because the machine not running smoothly at stable speed. Losses of speed also reflected to low performance of equipment. There are also issues of quality of the process and the vehicle, the number of defects per shift is 5 units from 50 units produced per shift. Therefore, the quality of the product decreased to 10 percent because of the product did not meet the specifications.

Any number of factors leading to low production output with machine operating time low. The maintenance department has been struggling to make a countermeasure with equipment be tracked in a problem. They have done a monthly maintenance practices in the last 3 months; however, the results did not show any significant progress in the breakdown of machinery. Given this situation, there is a need to observe and study the causes of machine damage and suggest the most appropriate method for further improvement that can benefit the production process.

1.3 PROBLEM STATEMENT

From the observation made in the Assembly Shop Chassis line, there have a number of machine breakdown, line stoppage cases through the production, the productivity not achieve the target and also the low product quality and affect the

Overall Equipment Effectiveness (OEE). So that, this research is to study and analyze the existing of Overall Equipment Effectiveness (OEE) and to propose on how to improve the productivity by reduced the machine breakdown, decrease the defects and increase the quality of productivity.

1.4 OBJECTIVE OF STUDY

This research was carried out to:

- To identify and analyse the elements of Overall Equipment Effectiveness (OEE).
- To calculate the existing of Overall Equipment Effectiveness (OEE).
- To evaluate, analyse and proposed improvement of the revised Overall Equipment Effectiveness (OEE).

1.5 SCOPE OF STUDY

The project objective is narrowed down by performing scopes of study.

- A case study will be conducted at Tan Chong Motor Assemblies Sdn. Bhd. On Assembly Shop Chassis line area.
- The study will be conducted for a period of 3 months for the latest Overall Equipment Effectiveness (OEE).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describes the principle of Overall Equipment Effectiveness and Total Productive Maintenance in general, and the principles behind the system. All related terms, terminology and formulas will be clearly stated.

2.2 HISTORY OF THE MAINTENANCE

Traditionally, maintenance is considered to be carried out to repair the broken machine, and the machine is considered to be fixed, to perform the operation correctly. Maintenance tasks are include re-adjust, replace parts or components, oil change, lubrication and cleaning (Sullivan, 2004). Literature maintenance often show flow changes from three generations before World War II had begun, as shown in Figure 2.1.

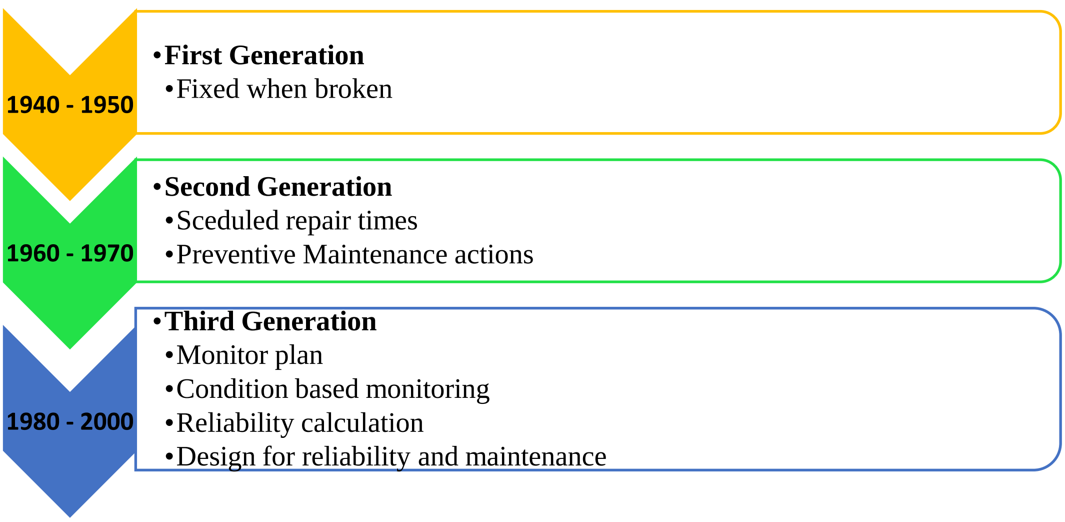

Figure 2.1: The Maintenance History

2.3 TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM is one of total quality culture that followed many good practices; it is through the use of lean principles to increase their competitiveness. The new assignment is likely to include improved equipment, repair, training, preventive maintenance, predictive maintenance. The task is transferred to production Kaizen including easy maintenance, cleaning, inspection, lubrication, and adjustments. Figure 2.2 shows schematically how TPM switch the stewardship of the Department of Production Maintenance team.

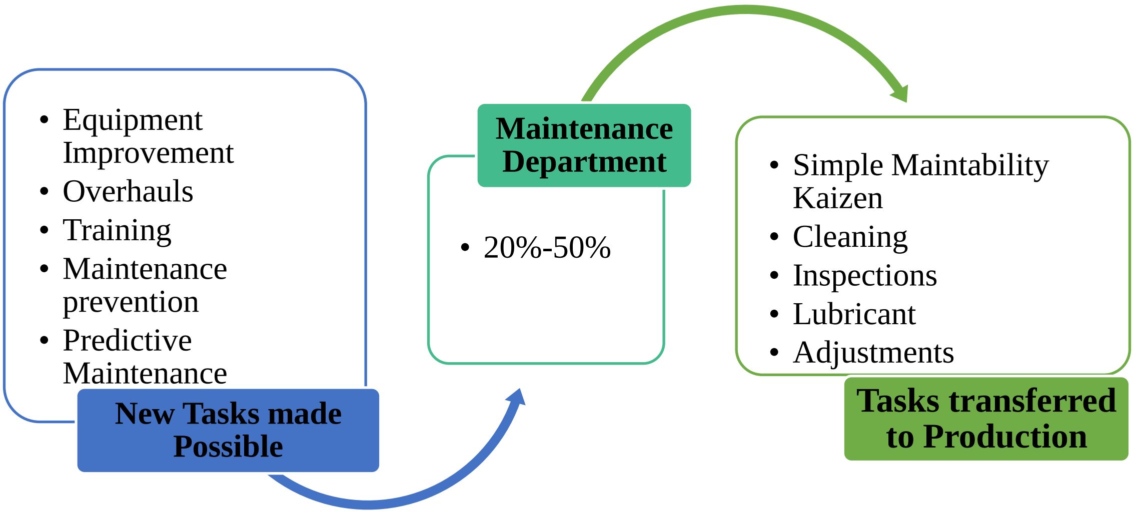

Figure 2.2: TPM Shifts Maintenance Tasks

2.3.1 Define Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) is a maintenance philosophy that requires total participation in the labour force. TPM combines the ease and availability of the skills of all employees with a focus on improving the overall efficiency of the facility. Efficiency is enhanced by eliminating the waste of time and resources. Typically, total productive maintenance is a concept that is easy to use for most of the manufacturing facility.

2.3.2 8 Pillar of TPM

Ahuja and Kamba (2008) was said that there is an eight pillar of TPM. By implementing all of these pillars, the TPM will function correctly and can absolutely help the company to achieve their goals. The eight pillars of TPM are mostly focused on proactive and preventative techniques for improving equipment reliability. The eight pillars of TPM illustrated in Figure 2.3.

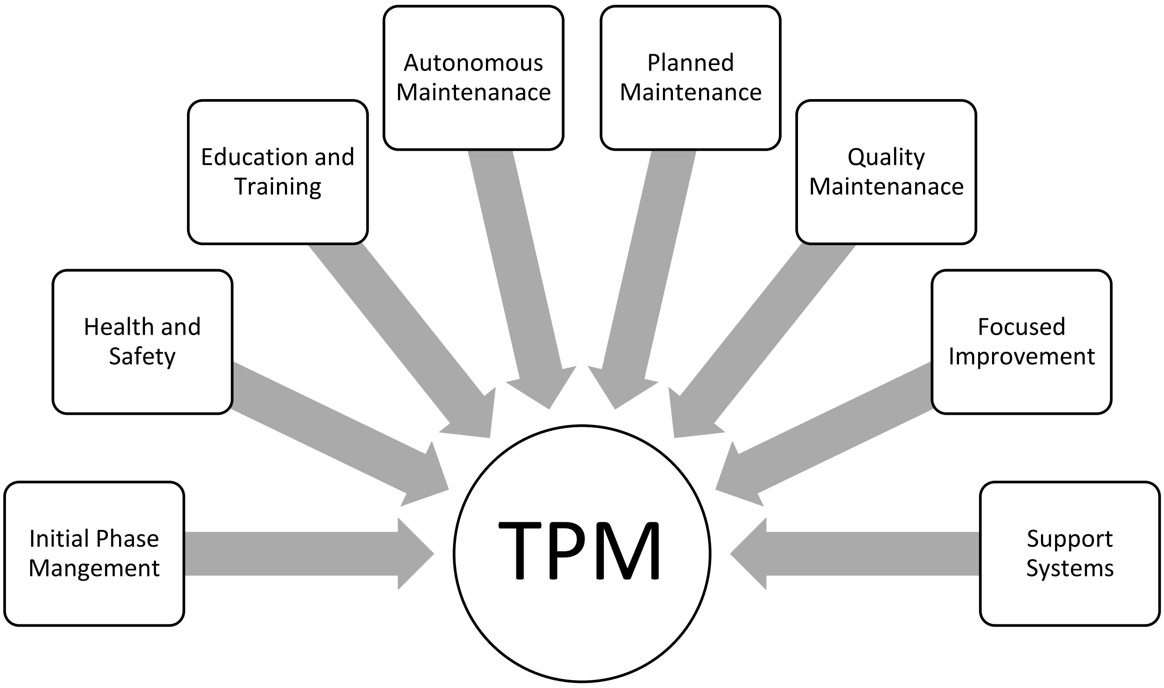

Figure 2.3: Eight Pillars Approach for TPM

2.4 OVERALL EQUIPMENT EFFECTIVENESS

OEE is a tools to measure and recognized that the equipment breakdown sources by production losses. OEE is a simple tool that will help managers to evaluate their effectiveness equipment. (Sermin Elevli and Birol Elevli 2010) It is the most common and important loss of productivity, which is called the six big losses and are given in Table 2.1. Equation below is to measure the equipment effectiveness.

$$OEE = Availability \times Performance \times Quality \quad (2.1)$$

Table 2.1: Six Big Losses of Equipment

Category	OEE Loss	Example
Breakdowns Setup adjustment	Availability	Tooling failures Setup / Changeover
Small stop Reduced speed	Performance	Cleaning / checking Inefficient operator
Startup rejects Production rejects	Quality	Incorrect assembly Scrap / rework

Overall equipment effectiveness (OEE) is a hierarchy of metrics developed by Seiichi Nakajima in (by Harrington Emerson in 1960 in a way of thinking about the labor efficiency) that evaluates and demonstrates how effective manufacturing operations used.

2.4.1 The Elements of Overall Equipment Effectiveness

Overall equipment effectiveness is calculated by combining three factors of the availability rate, the performance rate, and the quality rate.

Availability is the ratio of the amount of time that the tool capable to running a quality product to the total time it could be running. Availability rate can be defined as follows:

Availability = (Total Operating Time – Downtime) / Total Time Available (2.2)

Performance of tools is defined as the ratio of the amount of product made to the amount of target product that could be made. Then, performance is determined as follows:

Performance = number of unit manufactured / possible number of units (target) (2.3)

Quality of the product is the ratio of the amount of good products made to the total amount of product made. The rate of quality can be determined as follows:

Quality = number of goods unit produced / number of units produced (2.4)

2.4.2 World Class Ranking of OEE

Generally accepted world class target for each factor different from each other. Table 2.2 below shows the percentage of world class ranking of OEE.

Table 2.2: World Class of OEE Factor

OEE Factor	World Class
Availability	90.0%
Performance	95.0%
Quality	99.9%
Overall OEE	85.0%

2.5 PROCESS IMPROVEMENT TOOLS

Process improvement is important to be used to determine an ongoing process within the company to achieve target and objectives. The most used methods in the implementation process, tools and techniques will be shown as below:

i. Pareto analysis
ii. Cause And Effect Analysis
iii. Statistical Process Control (SPC) Charts
iv. 5 Whys Analysis
v. 5W IH Analysis

2.5.1 Pareto Charts

Pareto charts was invented by an economist who is Alfredo Pareto that listed that by a few people that controlled the most of the nation's wealth. Pareto charts is a simple method for identifying priority of changes to identify the problem. From this method, we can prioritize the most perfect state of individual modifications. Figure 2.4. shows the type of Pareto Charts.

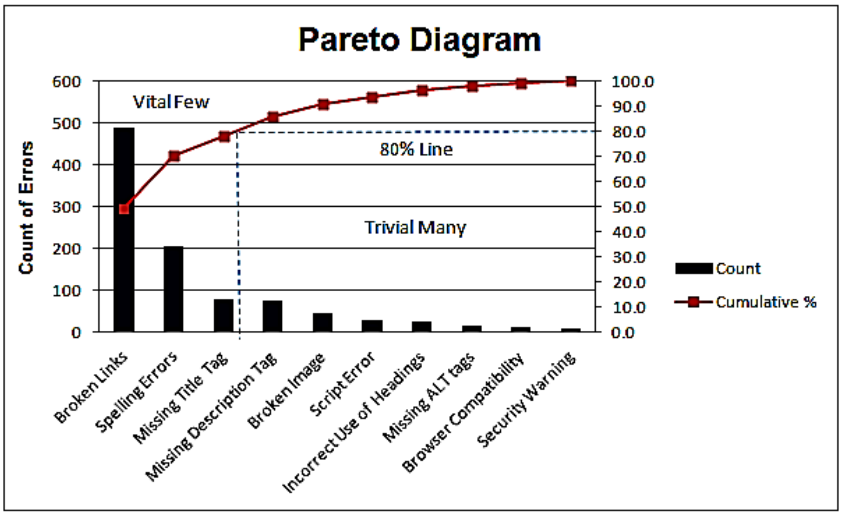

Figure 2.4: Pareto Chart

2.5.2 Ishikawa Diagram

Ishikawa diagram was invented by Kaoru Ishikawa. It is also called fishbone diagrams. Function of Ishikawa diagram is to identify the factors that are causes the undesired effect or defects. The major factors of the Ishikawa diagrams are Method, Man, Machine, Material and Environment. The completed Ishikawa diagram is shown in Figure 2.5.

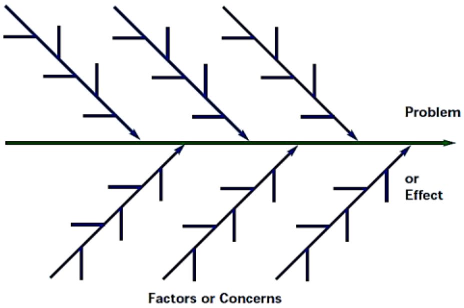

Figure 2.5: Ishikawa Diagram

2.5.3 Control Chart

A control chart is a graph used to study how the process of change over time. Data was plotted for the future control. Control charts always have a diameter of an average, the top line of the upper control limit and the lower line of the lower control limit.

2.5.4 5Whys Method

The 5-Whys Method was invented by Toyota Founder, Kiichiro Toyoda's father Sakichi and become popular in the 1970s by the Toyota Production System. The 5Whys Method is a strategy that involve in solving problem by looking at any problem asking: "Why?" and "What causes the problem?". It is a simple tool to determine the root cause of a problem. It can be done by using an innovative and creative technique, such as brainstorming, by asking questions repeatedly as shown in Figure 2.6.

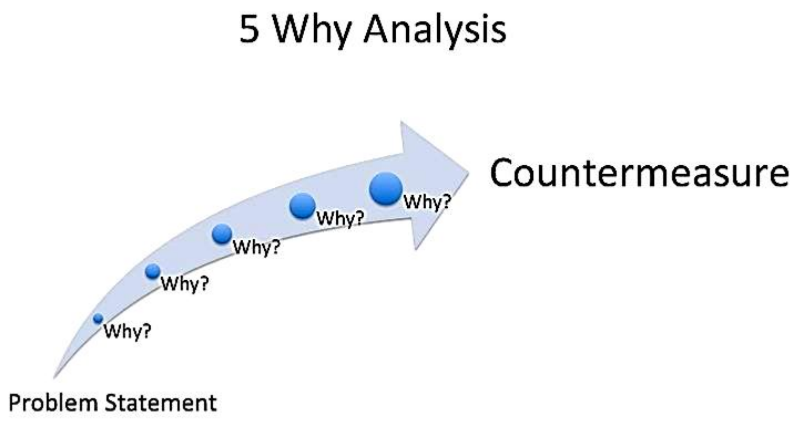

Figure 2.6: 5Whys Method

2.5.5 5W1H Method

5W1H shown in Figure 2.7 is the first problem solving tool in a team have been taught. This is the most recommended method to use initially. This method is not depends on technical skills and it is easy to used. This method ensures a team involved in problem solving process. Another way to help is brainstorming, which more reasons are described in Table 2.3. The 5W1H simple method can also be used to simplify the analysis process.

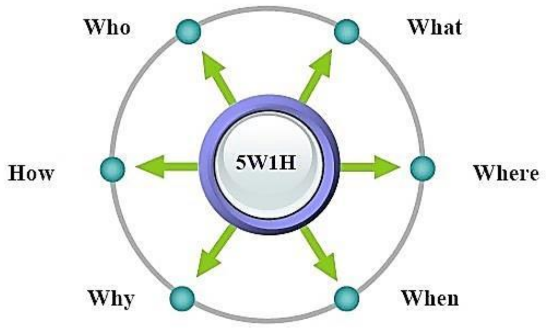

Figure 2.7: 5W1H Method

Table 2.3: 5W1H Analysis Example

What	What should be improved? What is the purpose of the improvement?
Where	Is the workers orientation or method correct when changing the workplace?
When	Change the time, period or sequence of the operation.
Who	Manpower, collaboration or task assignment. Check and discuss this issue again.
How	Is there better method to replace the current one?
Why	Why follow the present way. Is there any necessary change?

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the description of the methods to be used for this research. A methodology can be considered to include a various methods. It can be also defined as the study or description of methods. This study is based on observation on events happens in Tan Chong Motor Assemblies Sdn. Bhd. The flow chart in Figure 3.1 shows the steps that will be taken in this research.

3.2 EXPLANATION OF FLOWCHART

3.2.1 Research Background

In a field study of any organization that involves the establishment of information and reference real and tangible by the operator in the field. It can also be defined as a set of laboratory information and settings outside the workplace. This process involves the determination of accurate data on what is important, what kind of methods used included interviews informal group of direct observation, life group discussions, self-analysis, personal files, the resulting analysis, and the history of life.

At this level, the method used was to put to direct observation in order to gather information in an overview of the problems in selected company. First of all, the company must be selected to make observations and case studies. Application letter was drafted and sent to the Tan Chong Motor Assemblies Sdn Bhd. visit the company made an appointment before visiting. During the visit, an industrial engineer and plant manager briefly describes the background of the company; the type of products manufactured, their main customer and how the product is produced. After the presentation, a visit to the Department of Maintenance been held to get an overview of how the parts are produced. Some of the problems highlighted by the engineers and all the problems that were jotted down for analysis purposes.

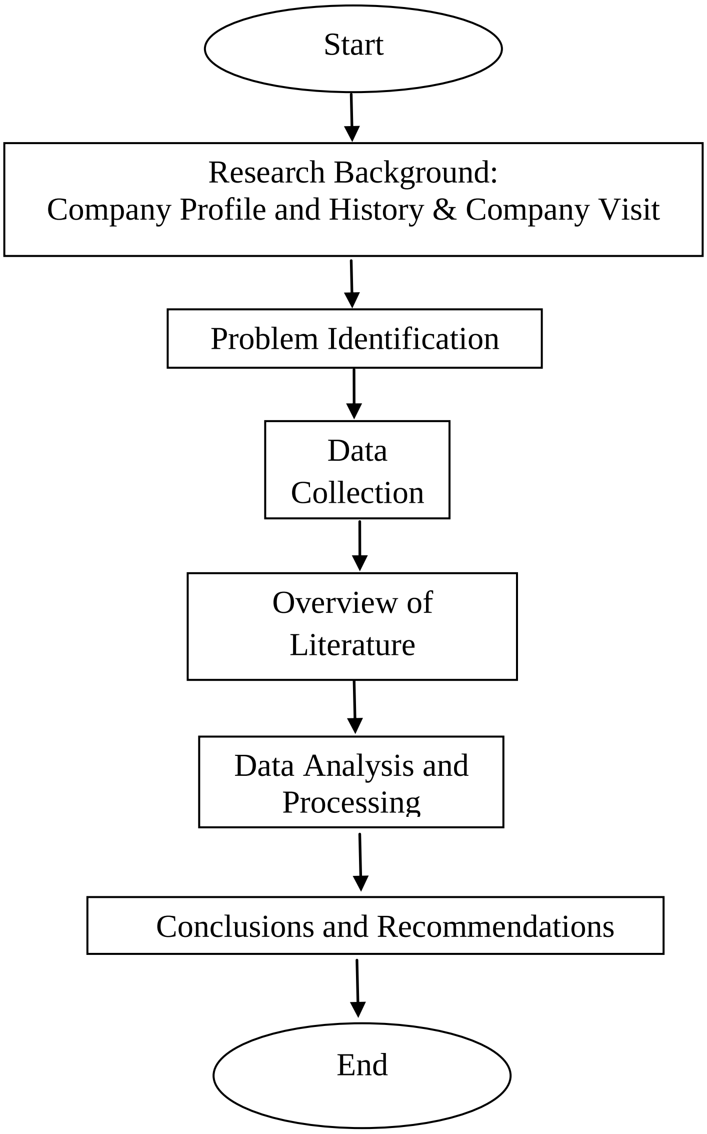

Figure 3.1: Flowchart of Study Framework

3.2.2 Problem Identification

Identification of the problem is defined as identify problems before trying to solve it. In other words, it is the first strategy in problem solving. First, we must realize and accept that there is a problem. Once a problem has been identified, then made direct observations. The information collected in connection with the problem as soon as possible to begin work on a solution.

3.2.3 Data Collection

Collection of data is defined as data collection and processing information by measuring the variables of interest, in a systematic pattern created that can answer research questions as stated, hypothesis testing, and evaluating results. The collection of data necessary step in order to establish a consistent analytical approach to problem occurs. The method of collecting data is to use Overall Equipment Effectiveness (OEE).

3.2.4 Overview of Literature

The literature review is conducted after the data is collected. In the literature review, similar methods are found from other journals, thesis, published papers, and articles. From the study, all the methods and solutions are summarized and the most suitable method is selected.

3.2.5 Data Analysis and Processing

The method of analysis will be carried out in the next chapter where to find the problem by using some of the tools that will be exposed. In order to find a solution, of data must be collected in accordance with the specification analysis. Analysis is the process of solving complex topic or issue into parts smaller in order to obtain a better understanding of it. In this study, of data relating collected and then move on to the next process of analyzing the of data. One of the main purposes of of data analysis is to find the cause of the problem, highlighting useful information, suggesting conclusions, and supporting decision making.

3.2.6 Conclusion and Recommendation

Various issues were integrated, covered in paper, and understanding into all comment. This includes observing the discussions, proposals, and further studies are required to remove any residue. It is recommended for future solutions to improve the OEE, in order to improve the efficiency of the equipment.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter will discuss the results of the study and presented the results in the industry related to real-time production monitoring system. This chapter will also show information and data to analyze and discuss.

Based on the results and information obtained from observations and records of the factory, there are a few tables, diagrams and graphs that have been built. There are several explanations for the details of the data and calculations are made to determine the availability and overall equipment per the last record.

4.2 DATA COLLECTION

4.2.1 Company Background

Tan Chong Motor Assemblies Sdn Bhd was choosen to be study in this studies. Tan Chong Motor Assemblies Sdn Bhd (TCMA) is a subsidiary of Tan Chong Motor Holdings (TCMH). Tan Chong Motor Holdings Berhad (TCMH) was incorporated in Malaysia on 14 October 1972. From the humble beginning as the distributor of small motor vehicles by its founders back in the 1950s, TCMH Group (the Group) has grown up into one of the largest national conglomerates involved in a myriad of business activities; from the assembly and marketing of motor vehicles and auto parts manufacturing to property development as well as trading in various heavy machineries, industrial equipment and consumer products both locally and abroad.

As part of a restructuring exercise to strengthen our foothold as an industry major player; in 1998 various business interests of TCMH abroad were eventually demerged and subsequently listed on The Stock Exchange of Hong Kong Limited under the Tan Chong International Limited flagship. This was followed by the demerger of its automotive parts division, non-motor division involving cosmetics, undergarments, and the distribution of heavy machinery as well as tourism-related businesses; which was subsequently listed on the Main Board of Bursa Malaysia Berhad in 1999 under APM Automotive Holdings Berhad and Warisan TC Holdings Berhad respectively. These exercises have enabled the Group to realign its focus on motor industry business.

TCMH is basically an investment holding company and the Group’s current principal activities among others are; assembly and distribution of motor vehicles, provision of after-sales services and motor related financial services such as hire purchase, an insurance agency, and leasing.

The Group is the franchise holder and exclusive distributor of Nissan passenger and light commercial vehicles as well as Renault vehicles in Malaysia. The vehicle distribution business is operated with an extensive network of sales branches and authorized dealership outlets nationwide; supported by more than 80 after-sales service centre. We are also the franchise holder and exclusive distributor for trucks and buses under the UD Trucks and Silverbus brands, operating through an established network of sales branches and sales dealers, after-sales branches and authorized service dealers. Having achieved a notable market share for heavy commercial vehicles (HCV), light commercial vehicles (LCV) and buses, the Group is recognized as one of the leading commercial vehicle distributors in Malaysia.

The two assembly plants in Segambut (Kuala Lumpur) and Serendah (Selangor) have very close capacity; both plants together can deliver 100,000 units a year with additional shift and reasonable overtime; the Group’s vehicles sales enjoyed a market share of 12.1% for non-national cars and 6.4% for the industry-wide market as of September 2014.

4.2.2 Corporate Logo

Figure 4.1: Tan Chong Motor Assemblies Sdn Bhd Corporate Logo

The four Discs represent four major diverse interest groups, namely: as Shareholders, Employees, Suppliers and Public and Customers. The position of the Discs portrays the four corners of the social economics of the nation – north, south, east and west – to where our business activities extend. The four Discs represent four major diverse interest groups, namely as Shareholders, Employees, Suppliers and Public and Customers.

The position of the Discs portrays the four corners of the social economics of the nation – north, south, east and west – to where our business activities extend.
The central inflated Red Cross represents the concerted efforts with which the company’s businessactivities are extended to the abovementioned four diverse groups in a systematic manner towards the attainment of our corporate objectives with increased prosperity.

The red which symbolises prosperity and blue which symbolises loyalty are colours technically chosen to highlight the image of the company and its subsidiaries. The factory was awarded the ISO 9001:2000 for Quality Management Systems (QMS) and ISO 14001:2004 for Environmental Management Systems (EMS).

4.2.2.1 Vision, Mission and Objective of Organization

Nissan is developing corporate activities centred on automobile manufacturing based on our vision of "enriching people's lives." In order for cars, which provide mobility, to truly become reliable partners for our customers, a number of issues including global environmental issues, traffic accidents and congestion problems must be tackled as part of a long-term vision. To realize our vision, Nissan is developing technologies based on a framework called the "Orchard" concept.Technical development encompasses a wide range of elements. It is necessary to think about how we will look at technology development and formulate strategies and plans for such development. For example, there are various technologies ranging from ones we wish to introduce onto the market right away, to basic ones that are developed slowly over time. The "Orchard" concept is an overall construct that allows us to think about these various technologies in a comprehensive manner.Nissan must have its own distinct value so that customers will choose Nissan cars. When combined, our activities to produce such value can be likened to the management of a fruit orchard in which "fruit" is planted and raised. The process is defined as having the following three phases.

1. Harvest Plan

First, we develop a plan for commercializing the technology. We clarify the value the technology holds for the target customers, who have been clearly defined based on the technology's performance and functions, as well as the time frame for the provision of the technology. We are not developing technology simply for technology's sake. We must formulate plans in conjunction with social needs and market demands in order to provide in a timely fashion value that pleases customers.

2. Seeding & Growth

Next, we plan the strategy and implementation that will make the Harvest Plan a reality. We specify what elemental technologies are needed in order to make the Harvest Plan a reality and form strategies for developing them quickly and at a high level of quality. We plan and implement partnerships with universities and suppliers, lobby government officials, establish new organizations and structures, make regular progress reviews, and continuously improve the technology after it has been introduced.

3. Soil Enrichment

This phase includes fundamental technologies and basic research, which are required competencies for continuing to create value in the long term. Some examples are technologies that improve reliability, which form the soil of the orchard; analysis and measurement technologies; and material technologies. In order to raise quality in the car manufacturing process, which runs from research and advanced development to car development, it is necessary to enrich the "soil" of the orchard with technology management that covers human resources and intrinsic company processes. Nissan's "orchard" includes a number of key technology areas, including the environment and safety. We discuss Harvest Plans for each area and plan and develop technologies for each over the mid and long terms.

4.2.2.1.1 Objective

4.2.2.1.1.1 Quality Policy

Aims to maintain and improve its position as high as quality automobile assembler by following quality policy

1. to continually satisfy customer requirements.
2. Company wide Quality Management System (QMS)
3. Manpower development through training and education.
4. Achieve built-in quality at lowest cost.

4.2.2.1.1.2 Environmental Policy

Tan Chong Motor Assemblies Sdn Bhd is committed and will endeavour

To comply and adhere to applicable law, regulations and other requirements in the interest of communities where we operate.

Continually improve environmental performance by actively pursuing pollution prevention, energy conservation and waste reduction.

5S Policy

We are committed to continuously maintain a high standard of 5S practices at our workplace though teamwork and self-discipline to improve quality, productivity and create harmonious and conducive working environment in line with Company Policy

4.2.3 Organizational Chart

There are 5 divisions in Tan Chong Motor Assemblies Sdn Bhd. The divisions at Tan Chong Motor consists of Manufacturing, Engineering Services, Finance, Admin, Multimedia System, General Admin, Purchasing and Local. Figure 4.2 shows the organizational chart of Tan Chong Motor Assemblies Sdn Bhd .

In the Manufacturing section, there is 4 department under this division. There is Body Shop, Paint Shop, Assembly Line and Logistics. Each of the department have their own responsible. For the Engineering Services there are 4 departments, each of the department have their own functions for the company. There is Nissan Production Way (NPW),Quality Department (QD),Production Engineering Department (PED), Maintenance and Jig. Under the Nissan Production Way (NPW) there is 3 sections, there is IE, GK and PPC. Another department is General Admin that responsible for the human resources, payroll, safety and hostel.

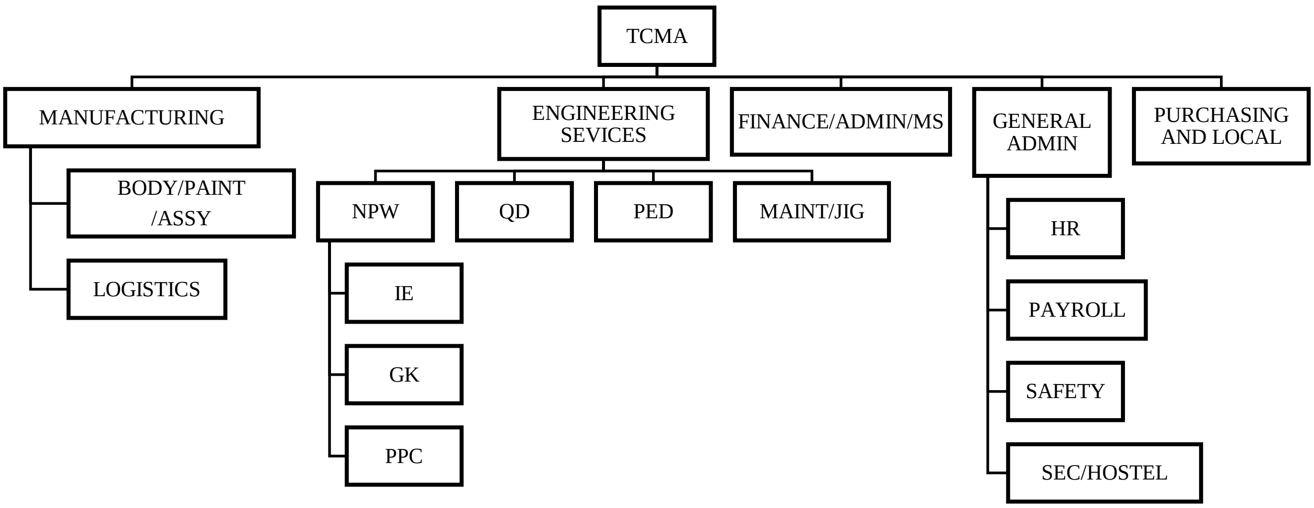

Figure 4.2: Organizational Chart of the Tan Chong Motor Assemblies Sdn Bhd

4.2.4 Manufacturing process of Tan Chong Motor Assemblies Sdn Bhd

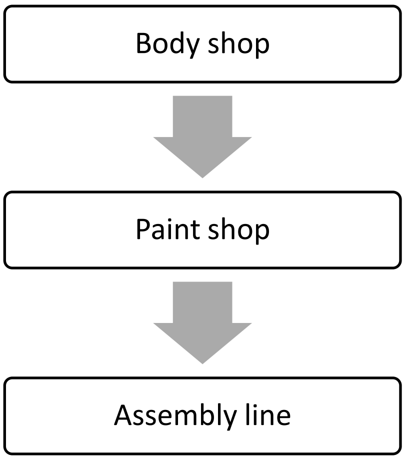

Figure 4.3: Process flow of Tan Chong Motor Assemblies Sdn Bhd Manufacturing

4.2.4.1 Body shop

The Body Shop is a highly automated section of the factory with robots in operation. Pressed-panels are welded together to create complete body shells.

4.2.4.2 Paint shop

Body shells are painted in a semi-clean environment using solvent-based paint. Shells are dipped in chemical tanks to cleanse them of any oils picked up on the panels during their manufacture in Body Shop. Once bodies have been dipped and cleansed, they are then immersed in an anti-corrosion paint dip called ED (Electrocoat Dip). This 'dip' coats the entire body, both inside and outside, and is the first paint coating it will receive. Once the 'dipped' body has been stoved in the ED oven, the body progresses to the 'Sealing' Booth. In this booth, the body has its interior panel joints, floor, tailgate, hood and door edges sealed with a PVC based sealant, to prevent water ingress and corrosion as the car is driven on the road. Also within this zone, sound pads are added to the floor and boot to reduce road noise (standard practice in the motor industry). The next booth it enters is the 'Underbody' Booth. In this booth, similar to 'Sealing' Booth, the body's wheel arches are sealed using the same PVC based sealant. Robots then apply the underseal to the underfloor and wheel arches. Also robots are used to apply the SGC (Stone Guard Coat) layer to the sills: this coating is designed for abrasion resistance, i.e. preventing stone chips, scuffs, etc. From here, the body proceeds into the Undercoat Oven. The next zone is 'ED Sanding' booth where the body is inspected for any minor imperfections received in the ED Coat. The next zone is the 'Surfacer' Booth, where the body receives its second coat of paint, this being the Surfacer Coat, then into the Surfacer Oven. Next is 'Surfacer Sanding' Booth: the same as ED Sanding, this zone inspects the body for any imperfections picked up within the Surfacer coating. Next comes the 'Topcoat' Booth, where the body receives its final coats of paint, these being Topcoat and Clearcoat layers. After being stoved in the Topcoat oven, the body then enters the 'Touch-up' Booth where the body has its final inspection for any imperfections picked up in the Topcoat process. Once the body leaves here, it then moves on to the PBS (Painted Body Store) above Trim and Chassis to await the next step in the production process.

4.2.4.3 Assembly Line

There are two parallel assembly lines in TCMA: Line A currently handles the P32R and J32Q; Line B handles the L02B and M11X. Painted bodies are stored in a large holding area called PBS (Painted Body Store), and are released in a specific scheduled sequence. They are brought into Trim & Chassis on suspended cradles. Each body moves through the assembly line and is fitted with interior (Trim), and exterior (Chassis) components. At one point in the process, the bodies are 'married' to a sub-assembled engine and subframe. Completed vehicles are sent down a Final Line, where all aspects of the car, from brakes to waterproofing, are tested. The car is then driven off-line to a holding area, ready to be distributed to a dealer

4.2.5 Process Flow in Chassis Line

Figure 4.4 shows the process happening in Chassis line, there are 12 sections for each process. After a trim line settles down, next to be chassis process that begins with process Underfloor 1 and 2 which include the process to fix the pipe, hose, and band assy fuel tank mounting into the front floor by using insulin heat and set control card. Next process of rear Axle sub 1 and 2 which is the process to fix and fit the component such ABS assy shock, hoist, tube assy brake and drive shaft at the rear beam. After that, Rear and Front Disc subprocess which install the front brake, adjust beam at brake assy and set hub at rear brake assy. Next, the process of engine mounting 1, 2 and 3 which include fix engine on left and right side, then fix the bracket assy torque and propeller shaft. After that, process engine sub 1 and 2 which include a process to fix the gearbox and assemble cable with harness and hose. Next, engine sub 3 added with engine drop which process include fixing alternator, compressor and motor assy, then mounting the engine with the front strut and tighten with oil disc. And then, process steering member combined with engine drop which is set the engine with the lifter and set drive shaft and rear disc and fix with struts. And then front axle with steering link which is the process to fix the engine frame with struts. Proceed into undercarriage process which is to assemble propeller shaft with disc stopper and adjust at the front disc, and then assemble extractor, cover the assay and exhaust sensor with gasket. Next process goes to engine room 1 and 2 and the engine room 3 which is fix torque road, duct assy air, battery bracket and front bumper. Lastly, process tire fitting which includes inserting tire and fixes the machine and runs the machine, after that install valve into tire lastly removes the tire from the machine . After chassis process done, it will next transfer into final line process.

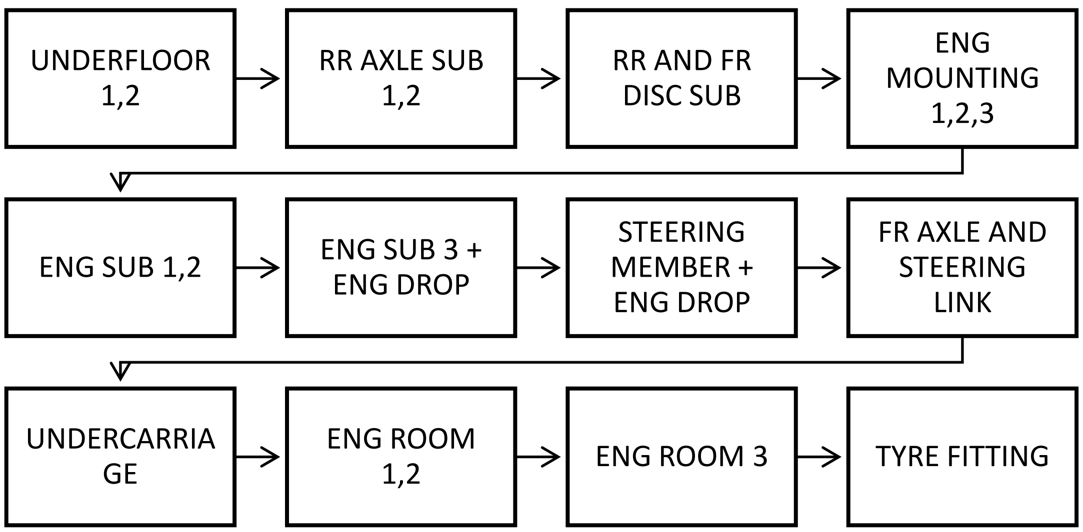

Figure 4.4: Process in Chassis Line

4.3 CURRENT CONDITION

In the beginning, data is recorded to identify any problems during the machine has been set up. Higher down time occurred during the preparation of the machine on which it will indicate the problem. The data will identify and count to get the OEE, availability, quality and performance. It intends to examine the problems affecting the OEE. In order to produce a better product at a lower damage, the company wants to cut their losses. The best products means that it comply with the specifications given.

Attribute data are typical for the size of the data or the sample size in the range of 50-10 per sample, it signifies a qualitative sample and good or bad. Using the p type of chart will calculate the percentage of defects in the sample. P chart will be built using Microsoft excel. Out of control chart, identify processes that are out of control. The process needs to be stabilized before it can improve the process of dealing with the problem.

Special causes require immediate analysis of cause and effect to eliminate variation. Once out of the control samples are removed (revised), attention will go to the control samples were sampled within the control limits. Then remove the samples will be carried out under the control limits (target). So last chart shows the maximum value of each of availability, performance, quality and overall equipment effectiveness. The investigation using Ishikawa diagrams necessary to determine whether a special reason will be changed. So from the same cause, it will use to solve problems in the production line.

4.3.1 Calculating Existing OEE

Table 4.1: Example of machine production data for sample on 01/07/2015 for Shift A

Production data	
Shift length	545 minutes
Tea breaks	15 minutes
Lunch break	35 minutes
Meeting, walking, 5S	21 minutes
Down time	71 minutes
Actual cycle time	7.18 minutes/unit
Total output	55 units
Offline unit	2 units
Net operation time = Total output per shift × actual cycle time	55 units × 7.18 minutes/unit = 395 minutes

Table 4.2: Processing data

Support variable	Calculation	Result
Planned production time	Total operating hours per shift – planned downtime per shift	453 minutes – 71 minutes = 474 minutes
Operation time	Planned production time – downtime loss- speed loss	474 minutes – 0 minute – 0 minute = 474 minutes
OK product	Total output per shift – offline unit per day	55 units – 2 units = 53 units

Table 4.3: Calculation of OEE factor

OEE factor	Calculation	OEE	%OEE
Availability	Operation time / planned production time	474 / 474 = 1.00	100
Performance	net operation time / operation time	395 / 474 = 0.833	83.3
Quality	OK product / total output	53 / 55 = 0.964	96.4
Overalll OEE	Availability × Performance × Quality	1.00 × 0.833 × 0.964 = 0.803	80.3

Table 4.1 shows the example of machine production data for sample on 01/07/2015 for Shift A in Chassis final, table 4.2 shows the processing data to calculate the support variable and table 4.3 shows the calculation to calculate the factor of availability, performance and quality to find the percentage of OEE factor.

4.4 DATA ANALYSIS

The process of evaluating data using analytical and logical reasoning to examine each component of the data provided. This form of analysis is just one of the many steps that must be completed when conducting a research experiment. Data from various sources is gathered, reviewed, and then analyzed to form some sort of finding or conclusion. There is a variety of specific data analysis method, some of which include data mining, text analytics, business intelligence, and data visualizations.

4.4.1 Current Condition Control Chart

Control chart is constructed to find the percentage value for each component in OEE of Availability, Performance and Quality. The pattern was observed in the control chart by supporting information gathered from the data collected.

4.4.1.1 Availability

4.4.1.1.1 Shift A

Table 4.4 shows the availability data get from plant and calculate using the p chart equation to get percentage of availability for shift A and shows the out of control point in the data. Above shows the calculation for availability factor on July 1st 2015 for Shift A for existing condition. Figure 4.5 shows the availability control chart for Shift A and constructed to find the percentage of availability pattern. Average value is 0.9909, while UCL and LCL value is vary based on their n number.

Table 4.4: control chart data for Availability in shift A

DAY	OPERATION TIME	PLANNED PRODUCTION TIME	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL	SIGMA P BAR	Z
1-Jul-15	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
2	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
3	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
6	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
7	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
8	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
9	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
10	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
11	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
13	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
14	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
22	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
23	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
24	472	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
27	463	474	0.98	0.9909	1.0040	0.9778	0.0044	3.0000
28	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
29	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
30	465	474	0.98	0.9909	1.0040	0.9778	0.0044	3.0000
3-Aug-15	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
4	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
5	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
6	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
7	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
10	448	474	0.95	0.9909	1.0040	0.9778	0.0044	3.0000
13	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
15	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
17	435	474	0.92	0.9909	1.0040	0.9778	0.0044	3.0000
18	525	534	0.98	0.9909	1.0032	0.9786	0.0041	3.0000
19	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
20	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
21	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
22	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
24	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
25	437	474	0.92	0.9909	1.0040	0.9778	0.0044	3.0000
26	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
27	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
3-Sep-15	523	534	0.98	0.9909	1.0032	0.9786	0.0041	3.0000
4	514	534	0.96	0.9909	1.0032	0.9786	0.0041	3.0000
10	466	474	0.98	0.9909	1.0040	0.9778	0.0044	3.0000
11	447	456	0.98	0.9909	1.0042	0.9776	0.0044	3.0000
12	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
14	479	484	0.99	0.9909	1.0038	0.9780	0.0043	3.0000
17	471	474	0.99	0.9909	1.0040	0.9778	0.0044	3.0000
18	534	534	1.00	0.9909	1.0032	0.9786	0.0041	3.0000
19	526	534	0.99	0.9909	1.0032	0.9786	0.0041	3.0000
21	475	479	0.99	0.9909	1.0039	0.9779	0.0043	3.0000
22	474	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
28-Sep	470	474	0.99	0.9909	1.0040	0.9778	0.0044	3.0000
29	460	474	0.97	0.9909	1.0040	0.9778	0.0044	3.0000
30	472	474	1.00	0.9909	1.0040	0.9778	0.0044	3.0000
	24136	24357	0.9909					

$$\bar{p} = \frac{24136}{24357}$$

$$= 0.9909$$

$$UCL_p = 0.9909 + 3\sqrt{\frac{0.9909\,(1-0.9909)}{474}}$$

$$= 1.0040$$

$$LCL_p = 0.9909 - 3\sqrt{\frac{0.9909\,(1-0.9909)}{474}}$$

$$= 0.9778$$

Figure 4.5: Control Chart for Availability in Shift A

4.4.1.1.2 Shift B

Figure 4.6 shows the availability control chart for Shift B and constructed to find the percentage of availability pattern. Average value is 0.999, while UCL and LCL value is varying based on their n number.

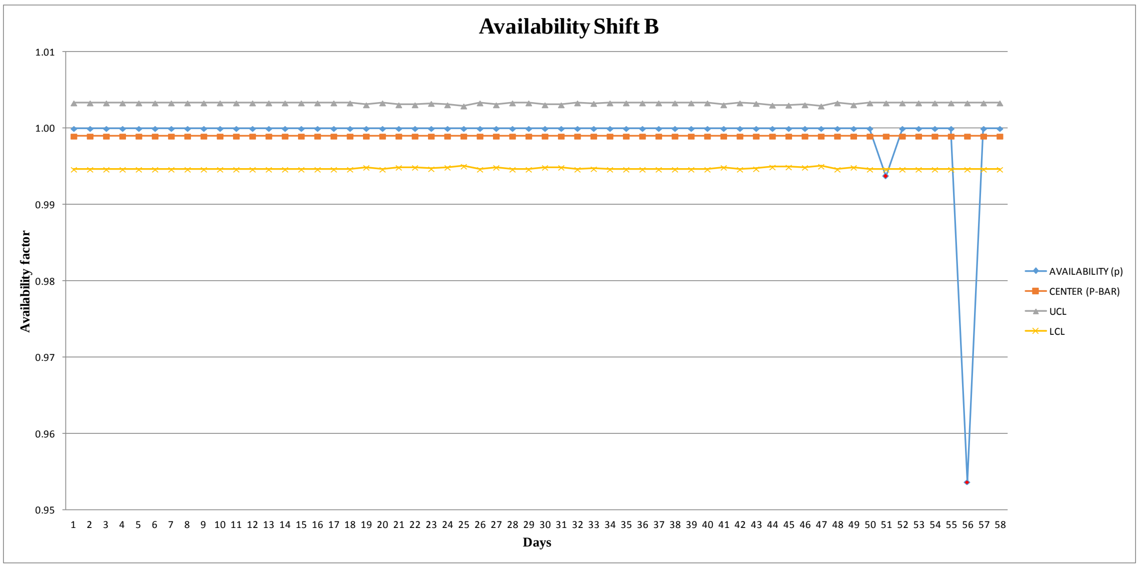

Figure 4.6: Control Chart for Availability in Shift B

Referring to figure 4.5 and figure 4.6, the process is out of control because there are points exceeding the control limit. However, point below the lower control limit are investigated and studied to help to increase the percentage in the future. The assignable cause responsible for the condition indicated that daily mechanical problems in this line, including machine breakdown and process quality problems.

4.4.1.2 Performance

4.4.1.2.1 Shift A

Table 4.5 shows the performance data get from plant and calculate using the p chart equation to get percentage of performance for shift A and shows the out of control point in the data. Above shows the calculation for performance factor on July 1st 2015 for Shift A for existing condition. Figure 4.7 shows the performance control chart for Shift A and constructed to find the percentage of availability pattern. Average value is 0.8507, while UCL and LCL value is vary based on their n number.

Table 4.5: control chart data for Performance in shift A

DAY	NET OPERATION TIME (np)	OPERATION TIME (n)	PERFORMANCE (p)	CENTER P BAR	UCL	LCL	SIGMA P BAR	Z
1-Jul-15	395	474	0.833	0.8507	0.8998	0.8016	0.0164	3
2	395	474	0.833	0.8507	0.8998	0.8016	0.0164	3
3	359	474	0.757	0.8507	0.8998	0.8016	0.0164	3
6	431	474	0.909	0.8507	0.8998	0.8016	0.0164	3
7	409	474	0.863	0.8507	0.8998	0.8016	0.0164	3
8	452	474	0.954	0.8507	0.8998	0.8016	0.0164	3
9	359	474	0.757	0.8507	0.8998	0.8016	0.0164	3
10	359	474	0.757	0.8507	0.8998	0.8016	0.0164	3
11	373	474	0.787	0.8507	0.8998	0.8016	0.0164	3
13	381	474	0.804	0.8507	0.8998	0.8016	0.0164	3
14	395	474	0.833	0.8507	0.8998	0.8016	0.0164	3
22	409	474	0.863	0.8507	0.8998	0.8016	0.0164	3
23	402	474	0.848	0.8507	0.8998	0.8016	0.0164	3
24	402	472	0.852	0.8507	0.8999	0.8015	0.0164	3
27	373	463	0.806	0.8507	0.9004	0.8010	0.0166	3
28	402	474	0.848	0.8507	0.8998	0.8016	0.0164	3
29	402	474	0.848	0.8507	0.8998	0.8016	0.0164	3
30	395	465	0.849	0.8507	0.9003	0.8011	0.0165	3
3-Aug-15	503	534	0.942	0.8507	0.8970	0.8044	0.0154	3
4	416	534	0.779	0.8507	0.8970	0.8044	0.0154	3
5	474	534	0.888	0.8507	0.8970	0.8044	0.0154	3
6	445	534	0.833	0.8507	0.8970	0.8044	0.0154	3
7	445	474	0.939	0.8507	0.8998	0.8016	0.0164	3
10	373	448	0.833	0.8507	0.9012	0.8002	0.0168	3
13	460	474	0.970	0.8507	0.8998	0.8016	0.0164	3
15	359	474	0.757	0.8507	0.8998	0.8016	0.0164	3
17	408	435	0.938	0.8507	0.9020	0.7994	0.0171	3
18	352	525	0.670	0.8507	0.8974	0.8040	0.0156	3
19	394	534	0.738	0.8507	0.8970	0.8044	0.0154	3
20	422	474	0.890	0.8507	0.8998	0.8016	0.0164	3
21	493	534	0.923	0.8507	0.8970	0.8044	0.0154	3
22	465	474	0.981	0.8507	0.8998	0.8016	0.0164	3
24	444	474	0.937	0.8507	0.8998	0.8016	0.0164	3
25	429	437	0.982	0.8507	0.9018	0.7996	0.0170	3
26	458	474	0.966	0.8507	0.8998	0.8016	0.0164	3
27	352	474	0.743	0.8507	0.8998	0.8016	0.0164	3
3-Sep-15	452	523	0.864	0.8507	0.8975	0.8039	0.0156	3
4	359	514	0.698	0.8507	0.8979	0.8035	0.0157	3
10	395	466	0.848	0.8507	0.9002	0.8012	0.0165	3
11	330	447	0.738	0.8507	0.9013	0.8001	0.0169	3
12	438	474	0.924	0.8507	0.8998	0.8016	0.0164	3
14	409	479	0.854	0.8507	0.8996	0.8018	0.0163	3
17	401	471	0.851	0.8507	0.9000	0.8014	0.0164	3
18	493	534	0.923	0.8507	0.8970	0.8044	0.0154	3
19	500	526	0.951	0.8507	0.8973	0.8041	0.0155	3
21	429	475	0.903	0.8507	0.8998	0.8016	0.0164	3
22	401	474	0.846	0.8507	0.8998	0.8016	0.0164	3
28-Sep	416	470	0.885	0.8507	0.9000	0.8014	0.0164	3
29	431	460	0.937	0.8507	0.9005	0.8009	0.0166	3
30	294	472	0.623	0.8507	0.8999	0.8015	0.0164	3
	20533	24136	0.8507					

$$\bar{p} = \frac{20533}{24136}$$

$$= 0.8507$$

$$UCL_p = 0.8507 + 3\sqrt{\frac{0.8507\,(1-0.8507)}{474}}$$

$$= 0.8998$$

$$LCL_p = 0.8507 - 3\sqrt{\frac{0.8507\,(1-0.8507)}{474}}$$

$$= 0.8016$$

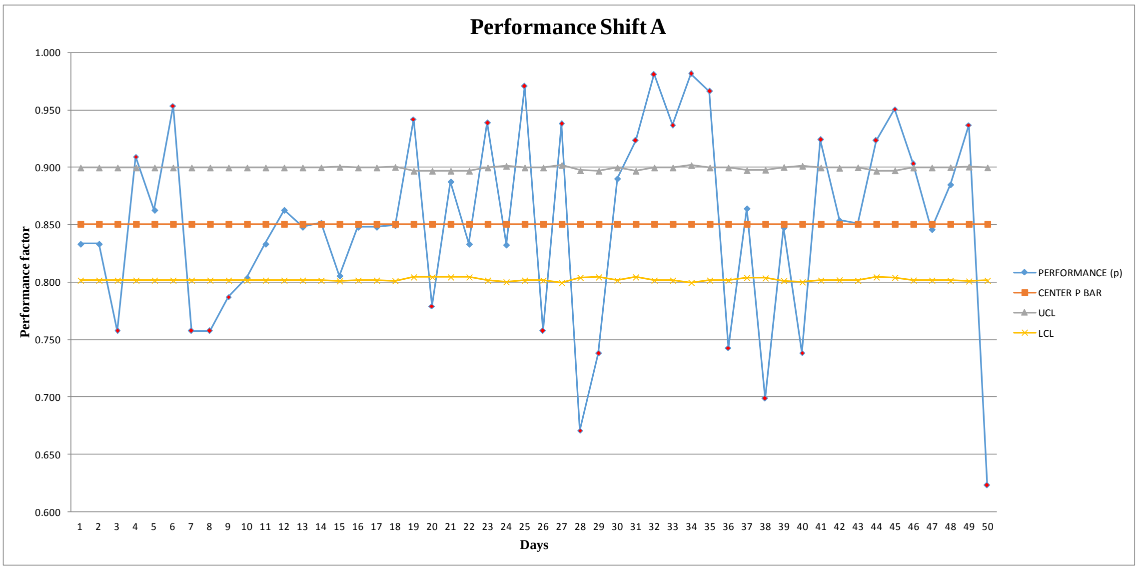

Figure 4.7: Control Chart for Performance in Shift A

4.4.1.2.2 Shift B

Figure 4.8 shows the performance control chart for Shift B and constructed to find the percentage of performance pattern. Average value is 0.8227, UCL and LCL value is varying because the n value is variable.

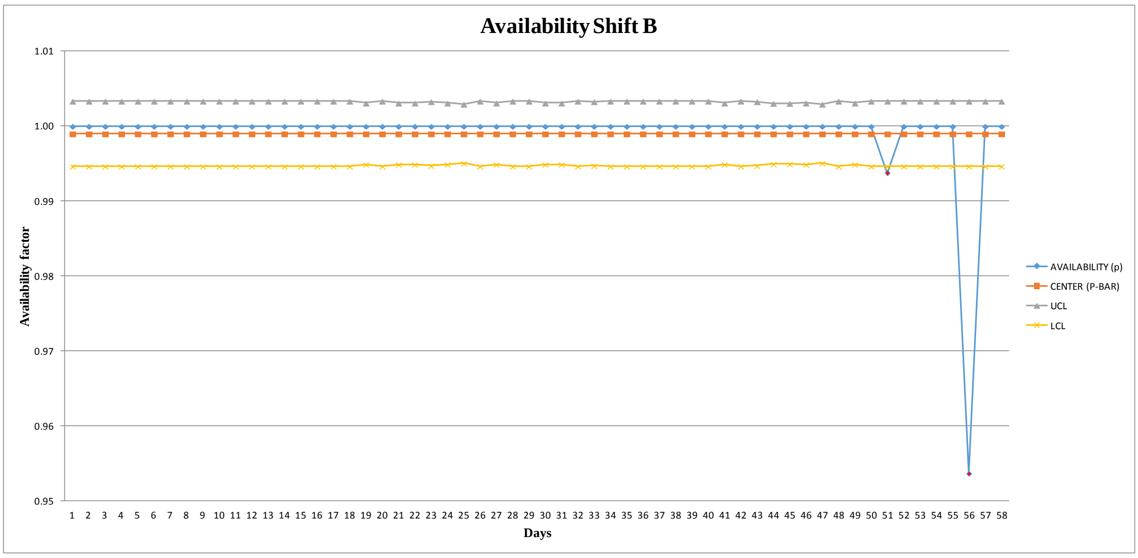

Figure 4.8: Control Chart for Performance in Shift B

Referring to figure 4.7 and figure 4.8, the process is out of control because there are points exceeding the control limit. However, point upper and lower control limit are investigated and studied to help to increase the percentage in the future. The assignable cause responsible for the condition indicated that daily mechanical problems in this line, including machine breakdown and process quality problems.

4.4.1.3 Quality

4.4.1.3.1 Shift A

Table 4.6 shows the quality data get from plant and calculate using the p chart equation to get percentage of quality for shift A and shows the out of control point in the data. Above shows the calculation for quality factor on July 1st 2015 for Shift A for existing condition. Figure 4.9 shows the quality control chart for Shift A and constructed to find the percentage of quality pattern. Average value is 0.9541, while UCL and LCL value is vary based on their n number.

Table 4.6: control chart data for Quality in shift A

DAY	OK PRODUCT PER SHIFT (np)	TOTAL OUTPUT PER SHIFT (n)	QUALITY (p)	CENTER (P-BAR)	UCL	LCL	SIGMA P-BAR	Z
1-Jul-15	53	55	0.9636	0.9541	1.0388	0.8694	0.0282	3
2	54	55	0.9818	0.9541	1.0388	0.8694	0.0282	3
3	50	50	1.0000	0.9541	1.0429	0.8653	0.0296	3
6	58	60	0.9667	0.9541	1.0351	0.8731	0.0270	3
7	56	57	0.9825	0.9541	1.0373	0.8709	0.0277	3
8	57	63	0.9048	0.9541	1.0332	0.8750	0.0264	3
9	47	50	0.9400	0.9541	1.0429	0.8653	0.0296	3
10	48	50	0.9600	0.9541	1.0429	0.8653	0.0296	3
11	50	52	0.9615	0.9541	1.0412	0.8670	0.0290	3
13	53	53	1.0000	0.9541	1.0403	0.8679	0.0287	3
14	54	55	0.9818	0.9541	1.0388	0.8694	0.0282	3
22	55	57	0.9649	0.9541	1.0373	0.8709	0.0277	3
23	54	56	0.9643	0.9541	1.0380	0.8702	0.0280	3
24	55	56	0.9821	0.9541	1.0380	0.8702	0.0280	3
27	52	52	1.0000	0.9541	1.0412	0.8670	0.0290	3
28	56	56	1.0000	0.9541	1.0380	0.8702	0.0280	3
29	54	56	0.9643	0.9541	1.0380	0.8702	0.0280	3
30	54	55	0.9818	0.9541	1.0388	0.8694	0.0282	3
3-Aug-15	68	70	0.9714	0.9541	1.0291	0.8791	0.0250	3
4	57	58	0.9828	0.9541	1.0365	0.8717	0.0275	3
5	64	66	0.9697	0.9541	1.0314	0.8768	0.0258	3
6	61	62	0.9839	0.9541	1.0338	0.8744	0.0266	3
7	58	62	0.9355	0.9541	1.0338	0.8744	0.0266	3
10	49	52	0.9423	0.9541	1.0412	0.8670	0.0290	3
13	60	64	0.9375	0.9541	1.0326	0.8756	0.0262	3
15	45	50	0.9000	0.9541	1.0429	0.8653	0.0296	3
17	52	58	0.8966	0.9541	1.0365	0.8717	0.0275	3
18	48	50	0.9600	0.9541	1.0429	0.8653	0.0296	3
19	53	56	0.9464	0.9541	1.0380	0.8702	0.0280	3
20	57	60	0.9500	0.9541	1.0351	0.8731	0.0270	3
21	66	70	0.9429	0.9541	1.0291	0.8791	0.0250	3
22	64	66	0.9697	0.9541	1.0314	0.8768	0.0258	3
24	61	63	0.9683	0.9541	1.0332	0.8750	0.0264	3
25	59	61	0.9672	0.9541	1.0345	0.8737	0.0268	3
26	62	65	0.9538	0.9541	1.0320	0.8762	0.0260	3
27	45	50	0.9000	0.9541	1.0429	0.8653	0.0296	3
3-Sep-15	62	63	0.9841	0.9541	1.0332	0.8750	0.0264	3
4	45	50	0.9000	0.9541	1.0429	0.8653	0.0296	3
10	55	55	1.0000	0.9541	1.0388	0.8694	0.0282	3
11	46	46	1.0000	0.9541	1.0467	0.8615	0.0309	3
12	61	61	1.0000	0.9541	1.0345	0.8737	0.0268	3
14	57	57	1.0000	0.9541	1.0373	0.8709	0.0277	3
17	43	57	0.7544	0.9541	1.0373	0.8709	0.0277	3
18	64	70	0.9143	0.9541	1.0291	0.8791	0.0250	3
19	66	71	0.9296	0.9541	1.0286	0.8796	0.0248	3
21	55	61	0.9016	0.9541	1.0345	0.8737	0.0268	3
22	55	57	0.9649	0.9541	1.0373	0.8709	0.0277	3
28-Sep	53	58	0.9138	0.9541	1.0365	0.8717	0.0275	3
29	60	60	1.0000	0.9541	1.0351	0.8731	0.0270	3
30	35	41	0.8537	0.9541	1.0521	0.8561	0.0327	3
	2746	2878	0.9541					

$$\bar{p} = \frac{2746}{2878}$$

$$= 0.9541$$

$$UCL_p = 0.9541 + 3\sqrt{\frac{0.9541\ (1-0.9541)}{55}}$$

$$= 1.0388$$

$$LCL_p = 0.9541 - 3\sqrt{\frac{0.9541\ (1-0.9541)}{55}}$$

$$= 0.8694$$

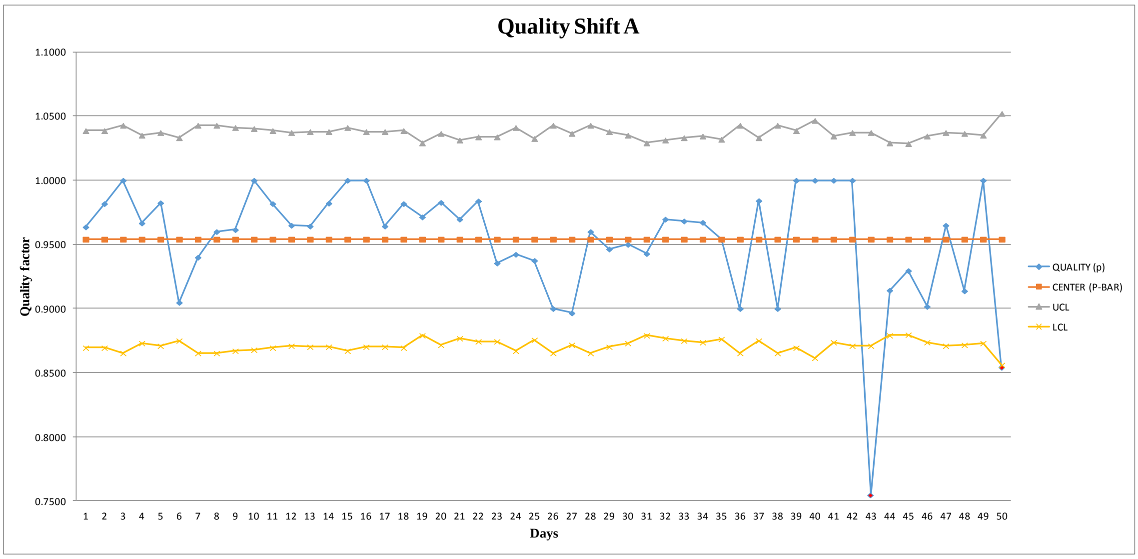

Figure 4.9: Control Chart for Quality in Shift A

4.4.1.3.2 Shift B

Figure 4.10 shows the quality control chart for Shift B and constructed to find the percentage of quality pattern. Average value is 0.9748, UCL and LCL value is varying because the n value is variable.

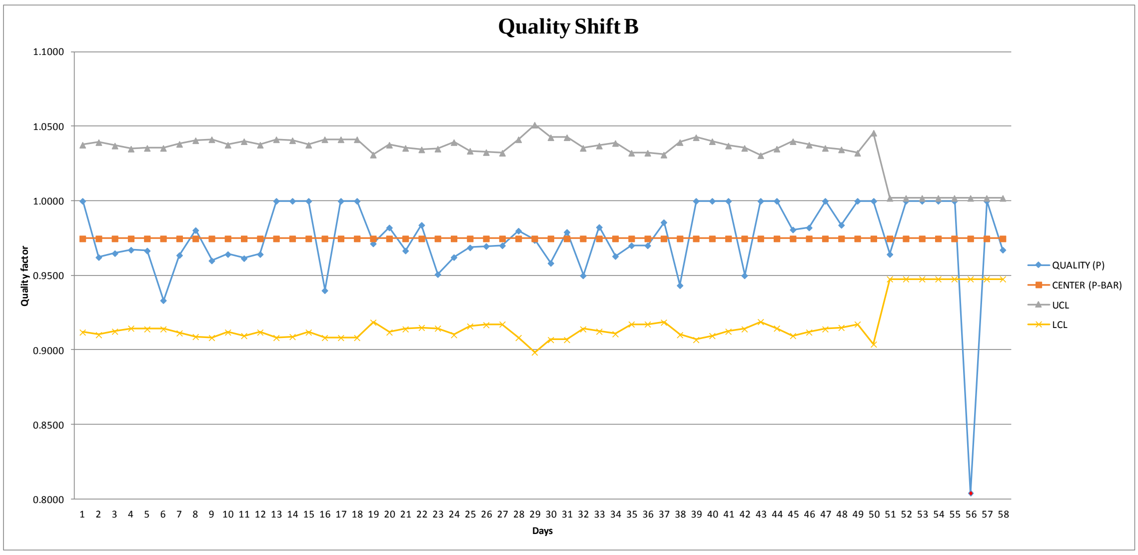

Figure 4.10: Control Chart for Quality in Shift B

Referring to figure 4.9 and figure 4.10, the process is out of control because there are points exceeding the control limit. However, point below the lower control limit are investigated and studied to help to increase the percentage in the future.

The assignable cause responsible for the condition indicated that daily mechanical problems in this line, including machine breakdown and process quality problems.

4.4.1.4 OEE

4.4.1.4.1 OEE shift A

Figure 4.11 shows the existing OEE in A shift compare with world class OEE. As it shown, it shows that there is a assignable cause in the control chart.

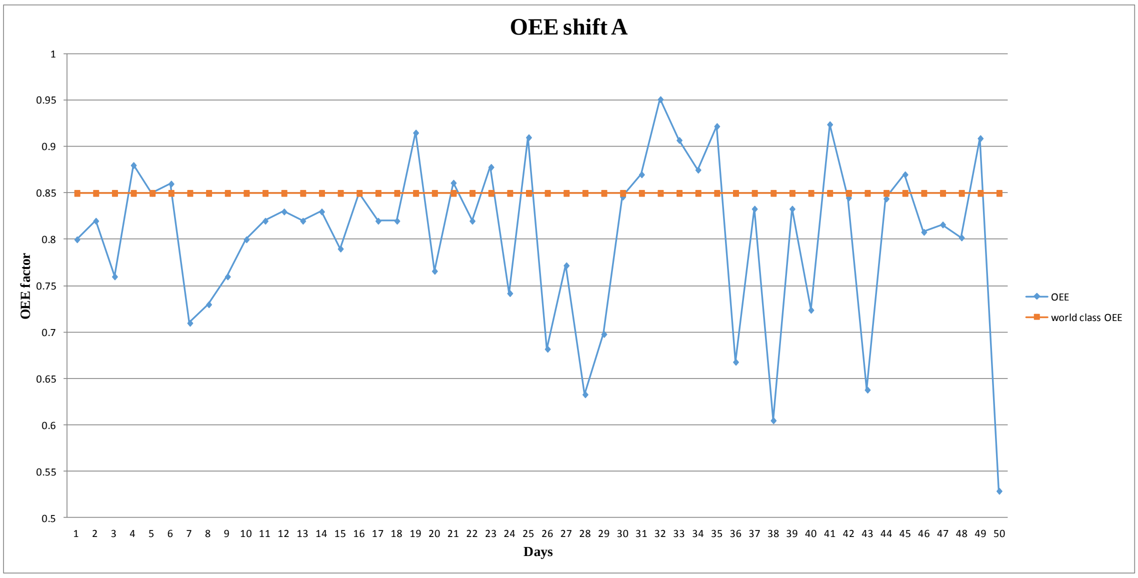

Figure 4.11: Control Chart for OEE Percentage in A Shift

4.4.1.4.2 OEE shift B

Figure 4.12 shows the existing OEE in B shift compare with world class OEE. As it shown, it shows that there is a assignable cause in the control chart.

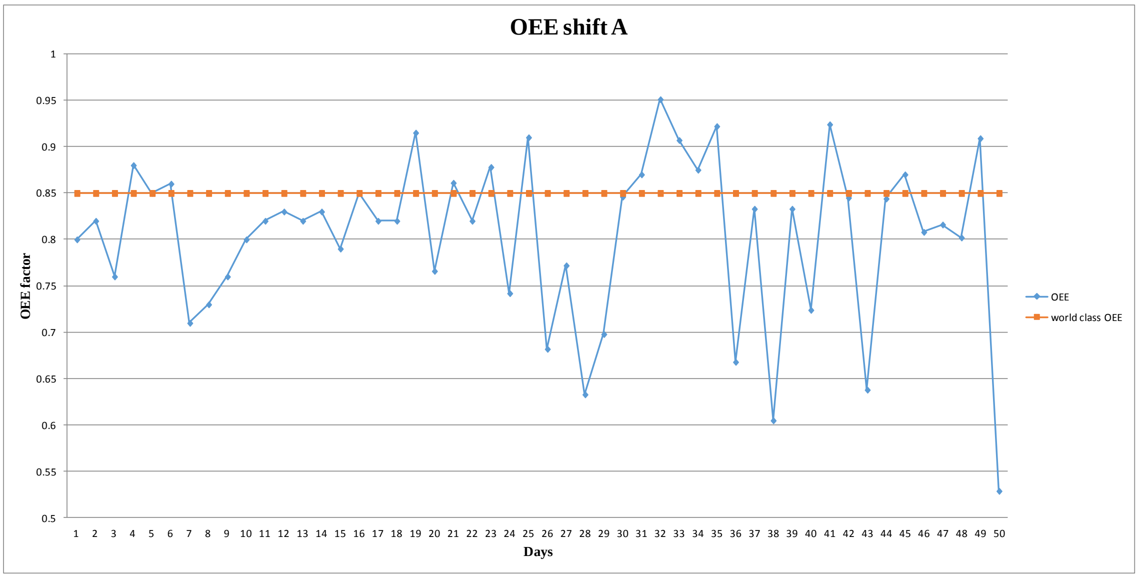

Figure 4.12: Control Chart for OEE Percentage in B Shift

4.4.1.5 Detailed explanation of point of out of control in control charts

4.4.1.5.1 Availability Factor

Based on Figure 4.5, it is noted that on date July 27th the availability percentage falls below the lower control limit of 97.78%.Besides, it also noted that on date August 10th, 17th, and 25th, the availability percentage falls below lower control limit of 97.78%. Similarly, it also noted that on date September 4th and 29th with availability percentage falls below lower limit of 97.86% and 97.78%. Although high percentage is preferable, the process aims to achieve a stable pattern. Therefore, the points are investigated before they are eliminated.

Based on figure 4.6, it is noted that on date September 17th and 28th the availability percentage falls below the lower control limit of 99.00%.

Based on the observation there is machine breakdown due to line stoppage reduction. Item to be countermeasure was door manipulator and air leak tester. First equipment is door manipulator than can't push up and down, this factor causes by hose leaking. Second equipment is air leak tester indicate a NG reading this phenomena is causes by hose bend. Countermeasure that can take action is to check, repair and properly layout the air hose of the equipment.

4.4.1.5.2 Performance Factor

Based on Figure 4.7, it is noted that on date July 3rd, 9th, 10th, and 11th with performance percentage falls below control limits of 80.22%. On July 6th, and 8th with performance percentage falls upper control limits of 90.02%. Although high percentage is preferable, the process aims to achieve a stable pattern. Besides, it is also noted that on date August 4th, 15th, 18th, 19th, and 27th with performance percentage falls below the lower control limit of 80.50%, 80.22%, 80.46%, 80.50% and 80.22%. on 3rd, 7th, 13th, 17th, 21th, 22th, 24th,25th, and 27th with performance percentage falls above the upper control limit of 89.74%, 90.02%, 90.02%, 90.24%, 89.74%, 90.02%, 90.02%,90.23 and 90.02%. Similarly, on September 4th, 11th, and 30th with performance percentage falls below the lower control limit of 80.41%, 80.07% and 80.21%. Therefore, the points are investigated before they are eliminated.

Similarly, based on Figure 4.8, it is noted that on date July 6th, 7th, 8th, with performance percentage falls above the upper control limit of 87.65%. On July 10th, 11th, 23th, 24th, 28th and 29th with performance percentage fall below the lower control limit of 77.15%. Besides, it is also noted that on date August 3rd, 7th, 13th, 14th, 20th, 24th, 25th and 26th the performance percentage respectively falls above the upper control limit of 87.34%, 87.57%, 87.65%, 87.34%, 87.65%, 87.65%, 87.65% and 87.6555%. On date August 10th, 15th, 17th, 18th and 19th with performance percentage falls below the lower control limit of 77.46%, 77.15%, 77.46% and 77.46%. on September 4th, 7th, 12th, 14th, 19th and 30th with performance percentage falls above the upper control limit of 87.65%, 87.57%, 87.65%, 87.34%, 87.65% and 87.65%.on September 1st, 3rd, 9th, 10th, 11th, 15th, 18th and 29th with performance percentage falls below the lower control limit of 77.15%, 77.46%, 77.51%, 77.46%, 77.64%, 77.15%,77.15%, and 77.15%.Therefore, the points are also investigated before they are eliminated.

Based on observation, there is problem with operator that has a bad attendance, factor of this situation is problem among operator. Secondly, miscommunication between operator and leader. Most of the operator is from outside from Malaysia, and it takes more than 3 months to teach them the language. Thirdly, some operator has to attend a training to improve their knowledge. This situation can be decrease by making a schedule to attend a training to prevent the operator missing from their workstation.

4.4.1.5.3 Quality Factor

Based on Figure 4.9, it is noted that on date 17th and 30th with quality percentage falls below the lower control limit of 87.06% and 85.57%.. Although high percentage is preferable, the process aims to achieve a stable pattern. Similar process pattern is also observed in Figure 4.10 on date September 28th with quality percentage falls below the lower control limit of 94.78%. These out-of-control points are investigated before they are eliminated.

Based on observation, there is downtime loss happen. This factor occur when there is machine breakdown and process quality issues. This issue happen when new operator operate the machine without supervised from leader. This issue can be reduced by attend a training to handle the machine.

4.4.2 1st Revised control chart

When a process is out of control, the assignable cause responsible for the condition must be found. Remove any points from the calculations that have been corrected. Revise the control charts with the remaining points. A new average can be obtained and set as a target value to make an improvement which can reduce downtime that affect OEE value.

Figure below shows the revised control chart for Chassis Assembly line in each shift and constructed to find average percentage in the process. The mean value in control chart is used as a value to propose a new target each OEE factor.

4.4.2.1 Availability

4.4.2.1.1 Shift A

Table 4.7 shows the data after revising the out of control point from the existing condition. Below shows the establish revised central line and control limits. Figure 4.13 shows the first revision of availability control chart for Shift A and constructed to find the percentage of availability pattern. Average value is 0.9966, while UCL and LCL value is vary based on their n number.

Table 4.7: revised control chart data for Availability in shift A

DAY	OPERATION TIME	PLANNED PRODUCTION TIME	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL	SIGMA P BAR	Z
1-Jul-15	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
2	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
3	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
6	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
7	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
8	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
9	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
10	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
11	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
13	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
14	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
22	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
23	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
24	472	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
28	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
29	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
30	465	474	0.98	0.9966	1.0046	0.9886	0.0027	3.0000
3-Aug-15	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
4	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
5	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
6	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
7	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
13	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
15	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
18	525	534	0.98	0.9966	1.0042	0.9890	0.0025	3.0000
19	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
20	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
21	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
22	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
24	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
26	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
27	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
3-Sep-15	523	534	0.98	0.9966	1.0042	0.9890	0.0025	3.0000
10	466	474	0.98	0.9966	1.0046	0.9886	0.0027	3.0000
11	447	456	0.98	0.9966	1.0048	0.9884	0.0027	3.0000
12	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
14	479	484	0.99	0.9966	1.0045	0.9887	0.0026	3.0000
17	471	474	0.99	0.9966	1.0046	0.9886	0.0027	3.0000
18	534	534	1.00	0.9966	1.0042	0.9890	0.0025	3.0000
19	526	534	0.99	0.9966	1.0042	0.9890	0.0025	3.0000
21	475	479	0.99	0.9966	1.0046	0.9886	0.0027	3.0000
22	474	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
28-Sep	470	474	0.99	0.9966	1.0046	0.9886	0.0027	3.0000
30	472	474	1.00	0.9966	1.0046	0.9886	0.0027	3.0000
	21379	21453	0.9966					

$$\bar{p} = \frac{21379}{21453}$$

$$= 0.9966$$

$$UCL_p = 0.9966 + 3\sqrt{\frac{0.9966\ (1-0.9966)}{474}}$$

$$= 1.0046$$

$$LCL_p = 0.9966 - 3\sqrt{\frac{0.9966\ (1-0.9966)}{474}}$$

$$= 0.9886$$

Figure 4.13: Control Chart for Revised Availability in Shift A

4.4.2.1.2 Shift B

Figure 4.14, shows the first revision of availability control chart for Shift B and constructed to find the percentage of availability pattern. Average value is 1.000, while UCL and LCL value is varying based on their n number.

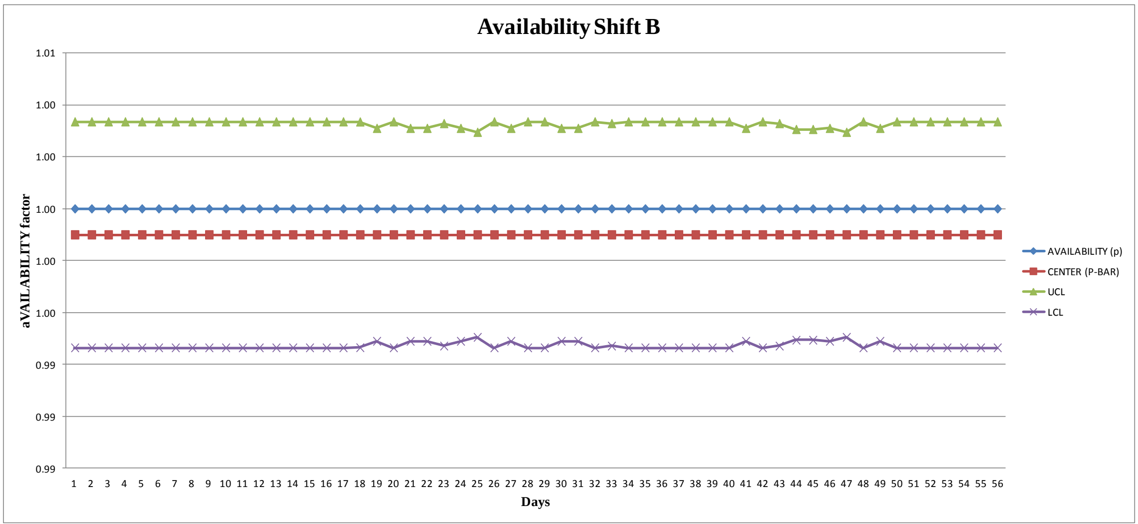

Figure 4.14: Control Chart for Revised Availability in Shift B

Apparently, the average value of availability percentage has increased after revising. Therefore, it is highly recommended to eliminate the assignable causes in the process in order to achieve the OEE value. Some of the point still out of control, however, this control chart can be revised again in order to achieve a stable level of process.

4.4.2.2 Performance

4.4.2.2.1 Shift A

Table 4.8 shows the data after revising the out of control point from the existing condition. Below shows the establish revised central line and control limits. Figure 4.15, shows the first revision of performance control chart for Shift A and constructed to find the percentage of performance pattern. Average value is 0.8490, UCL and LCL value is varying because the n value is variable.

Table 4.8: revised control chart data for Performance in shift A

DAY	NET OPERATION TIME (np)	OPERATION TIME (n)	PERFORMANCE (p)	CENTER P BAR	UCL	LCL	SIGMA P BAR	Z
1-Jul-15	395	474	0.833	0.8490	0.8983	0.7997	0.0164	3
2	395	474	0.833	0.8490	0.8983	0.7997	0.0164	3
7	409	474	0.863	0.8490	0.8983	0.7997	0.0164	3
13	381	474	0.804	0.8490	0.8983	0.7997	0.0164	3
14	395	474	0.833	0.8490	0.8983	0.7997	0.0164	3
22	409	474	0.863	0.8490	0.8983	0.7997	0.0164	3
23	402	474	0.848	0.8490	0.8983	0.7997	0.0164	3
24	402	472	0.852	0.8490	0.8984	0.7996	0.0165	3
27	373	463	0.806	0.8490	0.8989	0.7991	0.0166	3
28	402	474	0.848	0.8490	0.8983	0.7997	0.0164	3
29	402	474	0.848	0.8490	0.8983	0.7997	0.0164	3
30	395	465	0.849	0.8490	0.8988	0.7992	0.0166	3
5	474	534	0.888	0.8490	0.8955	0.8025	0.0155	3
6	445	534	0.833	0.8490	0.8955	0.8025	0.0155	3
10	373	448	0.833	0.8490	0.8997	0.7983	0.0169	3
20	422	474	0.890	0.8490	0.8983	0.7997	0.0164	3
3-Sep-15	452	523	0.864	0.8490	0.8960	0.8020	0.0157	3
10	395	466	0.848	0.8490	0.8988	0.7992	0.0166	3
14	409	479	0.854	0.8490	0.8981	0.7999	0.0164	3
17	401	471	0.851	0.8490	0.8985	0.7995	0.0165	3
22	401	474	0.846	0.8490	0.8983	0.7997	0.0164	3
28-Sep	416	470	0.885	0.8490	0.8985	0.7995	0.0165	3
	8948	10539	0.8490					

$$\bar{p} = \frac{21379}{21453}$$

$$= 0.9966$$

$$UCL_p = 0.9966 + 3\sqrt{\frac{0.9966\,(1-0.9966)}{474}}$$

$$= 1.0046$$

$$LCL_p = 0.9966 - 3\sqrt{\frac{0.9966\,(1-0.9966)}{474}}$$

$$= 0.9886$$

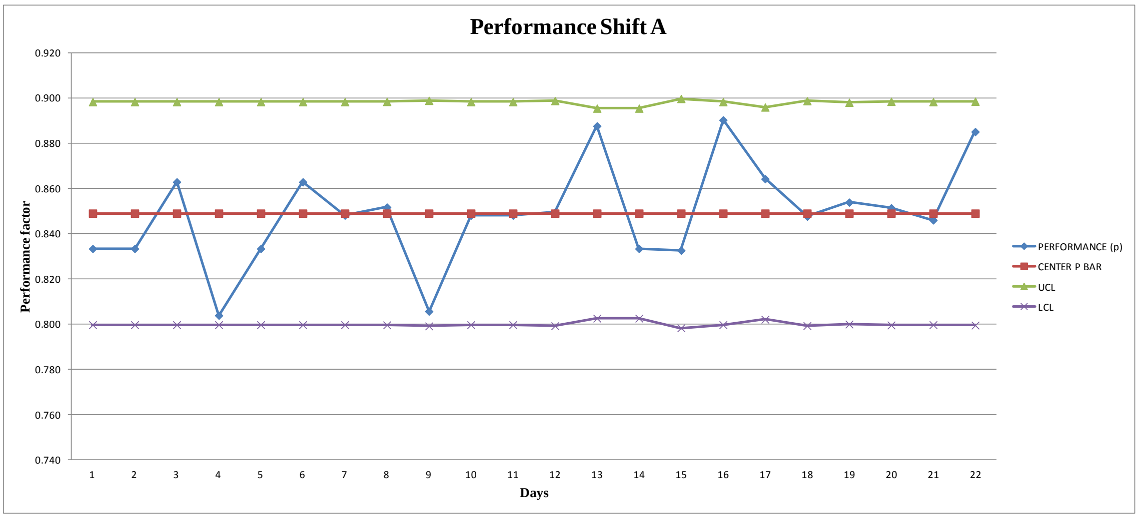

Figure 4.15: Control Chart for Performance in Shift A

4.4.2.2.2 Shift B

Figure 4.16, shows the first revision of performance control chart for Shift B and constructed to find the percentage of performance pattern. Average value is 0.8287, UCL and LCL value is varying because the n value is variable.

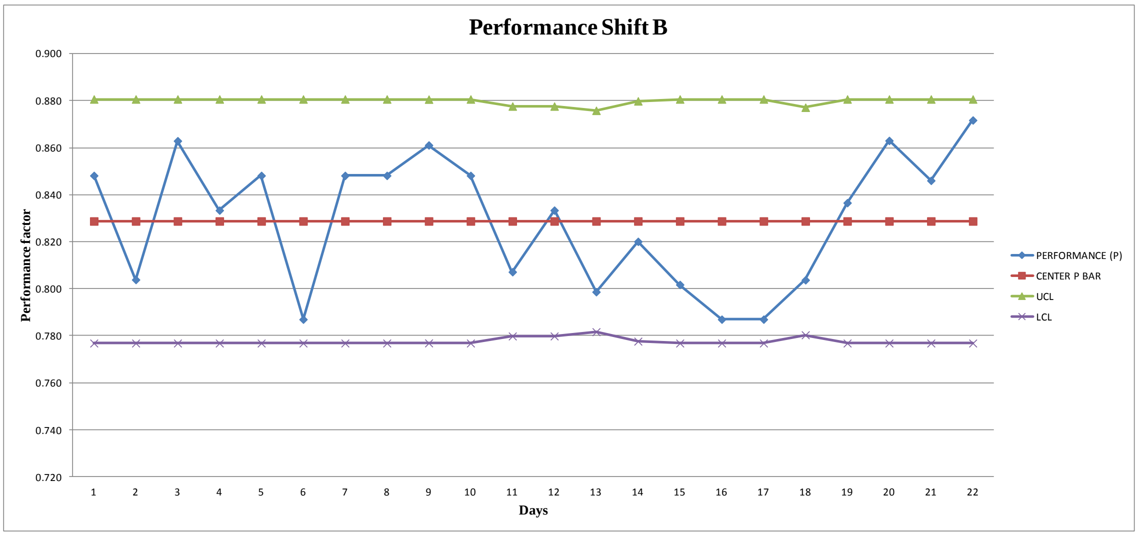

Figure 4.16: Control Chart Revised for Performance in Shift B

Apparently, the average value of performance percentage has increased after revising. Therefore, it is highly recommended to eliminate the assignable causes in the process in order to achieve the OEE value.

4.4.2.3 Quality

4.4.2.3.1 Shift A

Table 4.9 shows the data after revising the out of control point from the existing condition. Below shows the establish revised central line and control limits. Figure 4.17 shows the first revision of quality control chart for Shift A and constructed to find the percentage of quality pattern. Average value is 0.9597, UCL and LCL value is varying because the n value is variable.

Table 4.9: revised control chart data for Quality in shift A

DAY	OK PRODUCT PER SHIFT (np)	TOTAL OUTPUT PER SHIFT (n)	QUALITY (p)	CENTER (P-BAR)	UCL	LCL	SIGMA P-BAR	Z
1-Jul-15	53	55	0.9636	0.9597	1.0393	0.8801	0.0265	3
2	54	55	0.9818	0.9597	1.0393	0.8801	0.0265	3
3	50	50	1.0000	0.9597	1.0431	0.8763	0.0278	3
6	58	60	0.9667	0.9597	1.0359	0.8835	0.0254	3
7	56	57	0.9825	0.9597	1.0378	0.8816	0.0260	3
8	57	63	0.9048	0.9597	1.0340	0.8854	0.0248	3
9	47	50	0.9400	0.9597	1.0431	0.8763	0.0278	3
10	48	50	0.9600	0.9597	1.0431	0.8763	0.0278	3
11	50	52	0.9615	0.9597	1.0415	0.8779	0.0273	3
13	53	53	1.0000	0.9597	1.0407	0.8787	0.0270	3
14	54	55	0.9818	0.9597	1.0393	0.8801	0.0265	3
22	55	57	0.9649	0.9597	1.0378	0.8816	0.0260	3
23	54	56	0.9643	0.9597	1.0385	0.8809	0.0263	3
24	55	56	0.9821	0.9597	1.0385	0.8809	0.0263	3
27	52	52	1.0000	0.9597	1.0415	0.8779	0.0273	3
28	56	56	1.0000	0.9597	1.0385	0.8809	0.0263	3
29	54	56	0.9643	0.9597	1.0385	0.8809	0.0263	3
30	54	55	0.9818	0.9597	1.0393	0.8801	0.0265	3
3-Aug-15	68	70	0.9714	0.9597	1.0302	0.8892	0.0235	3
4	57	58	0.9828	0.9597	1.0372	0.8822	0.0258	3
5	64	66	0.9697	0.9597	1.0323	0.8871	0.0242	3
6	61	62	0.9839	0.9597	1.0346	0.8848	0.0250	3
7	58	62	0.9355	0.9597	1.0346	0.8848	0.0250	3
10	49	52	0.9423	0.9597	1.0415	0.8779	0.0273	3
13	60	64	0.9375	0.9597	1.0334	0.8860	0.0246	3
15	45	50	0.9000	0.9597	1.0431	0.8763	0.0278	3
17	52	58	0.8966	0.9597	1.0372	0.8822	0.0258	3
18	48	50	0.9600	0.9597	1.0431	0.8763	0.0278	3
19	53	56	0.9464	0.9597	1.0385	0.8809	0.0263	3
20	57	60	0.9500	0.9597	1.0359	0.8835	0.0254	3
21	66	70	0.9429	0.9597	1.0302	0.8892	0.0235	3
22	64	66	0.9697	0.9597	1.0323	0.8871	0.0242	3
24	61	63	0.9683	0.9597	1.0340	0.8854	0.0248	3
25	59	61	0.9672	0.9597	1.0352	0.8842	0.0252	3
26	62	65	0.9538	0.9597	1.0329	0.8865	0.0244	3
27	45	50	0.9000	0.9597	1.0431	0.8763	0.0278	3
3-Sep-15	62	63	0.9841	0.9597	1.0340	0.8854	0.0248	3
4	45	50	0.9000	0.9597	1.0431	0.8763	0.0278	3
10	55	55	1.0000	0.9597	1.0393	0.8801	0.0265	3
11	46	46	1.0000	0.9597	1.0467	0.8727	0.0290	3
12	61	61	1.0000	0.9597	1.0352	0.8842	0.0252	3
14	57	57	1.0000	0.9597	1.0378	0.8816	0.0260	3
18	64	70	0.9143	0.9597	1.0302	0.8892	0.0235	3
19	66	71	0.9296	0.9597	1.0297	0.8897	0.0233	3
21	55	61	0.9016	0.9597	1.0352	0.8842	0.0252	3
22	55	57	0.9649	0.9597	1.0378	0.8816	0.0260	3
28-Sep	53	58	0.9138	0.9597	1.0372	0.8822	0.0258	3
29	60	60	1.0000	0.9597	1.0359	0.8835	0.0254	3
	2668	2780	0.9597					

$$\bar{p} = \frac{2668}{2780}$$

$$= 0.9597$$

$$UCL_p \;=\; 0.9597 + \;3\sqrt{\frac{0.9597\,(1-0.9597)}{55}}$$

$$=\; 1.0393$$

$$LCL_p \;= 0.9597 - \;3\sqrt{\frac{0.9597\,(1-0.9597)}{55}}$$

$$= 0.8801$$

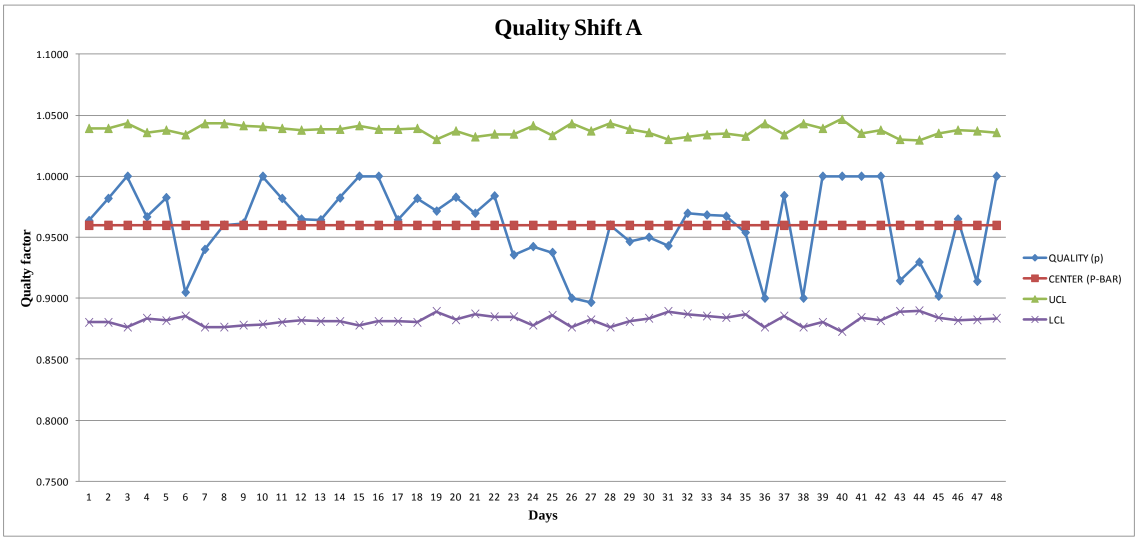

Figure 4.17: Control Chart Revised for Quality in Shift A

4.4.2.3.2 Shift B

Figure 4.18 shows the first revision of quality control chart for Shift B and constructed to find the percentage of quality pattern. Average value is 0.9777, UCL and LCL value is varying because the n value is variable.

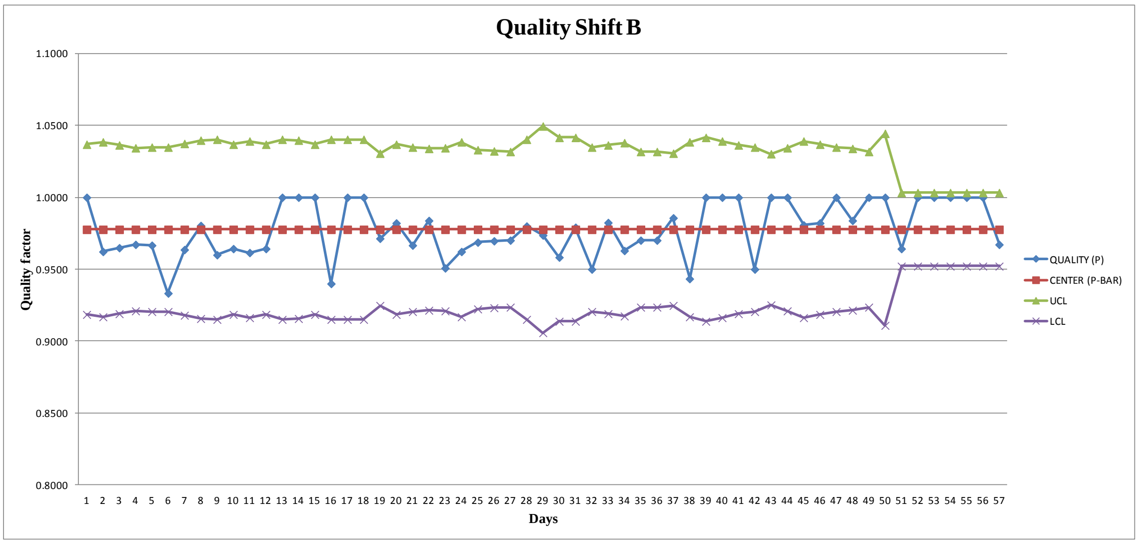

Figure 4.18: Control Chart Revised for Quality in Shift B

Apparently, the average value of quality percentage has increased after revising. Therefore, it is highly recommended to eliminate the assignable causes in the process in order to achieve the OEE value.

4.4.3 2nd Revised Control Chart

Figure below shows the 2nd revised control chart for Chassis Assembly line in each shift and constructed by eliminate the assignable cause point to get a stable control chart. The mean value in control chart is used as a value to propose a new target each OEE factor.

4.4.3.1 Availability

4.4.3.1.1 Shift A

Table 4.10 shows the data after eliminated the below point of central line to get a stable control chart. Below shows the establish central line and control limits for 2nd revised. Figure 4.19 shows the second revision of availability control chart for Shift A and constructed to find the percentage of availability pattern. Average value is 0.99, UCL and LCL value is varying because the n value is variable.

Table 4.10: 2nd revised control chart data for Availability in shift A

DAY	OPERATION TIME	PLANNED PRODUCTION TIME	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL	SIGMA P BAR	Z
1-Jul-15	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
2	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
3	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
6	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
7	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
8	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
9	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
10	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
11	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
13	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
14	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
22	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
23	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
28	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
29	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
3-Aug-15	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
4	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
5	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
6	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
7	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
13	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
15	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
19	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
20	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
21	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
22	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
24	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
26	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
27	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
12	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
18	534	534	1.00	0.9900	1.0029	0.9771	0.0043	3.0000
22	474	474	1.00	0.9900	1.0037	0.9763	0.0046	3.0000
	15588	15588	1.0000					

$$\bar{p} = \frac{15588}{15588}$$

$$= 1.000$$

$$UCL_p = 1.000 + 3\sqrt{\frac{1.000\ (1-1.000)}{474}}$$

$$= 1.0037$$

$$LCL_p = 1.000 - 3\sqrt{\frac{1.000\ (1-1.000)}{474}}$$

$$= 0.9763$$

Figure 4.19: Control Chart 2nd Revised for Availability in Shift A

4.4.3.1.2 Shift B

Figure 4.20 shows the second revision of availability control chart for Shift B and constructed to find the percentage of availability pattern. Average value is 0.99, UCL and LCL value is varying because the n value is variable.

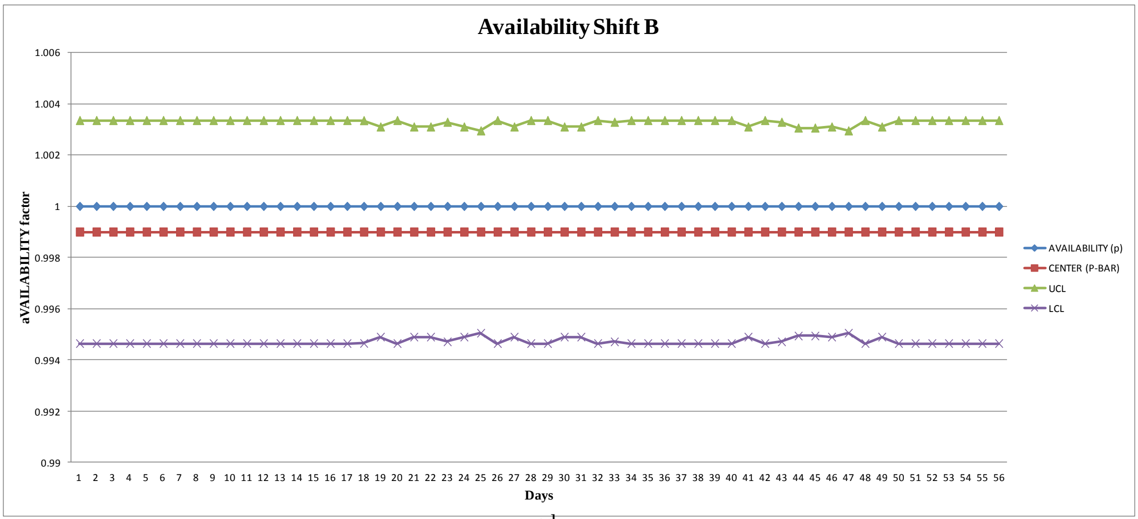

Figure 4.20: Control Chart 2nd Revised for Availability in Shift B

4.4.3.2 Performance

4.4.3.2.1 Shift A

Table 4.11 shows the data after eliminated the below point of central line to get a stable control chart. Below shows the establish central line and control limits for 2nd revised. Figure 4.21 shows the second revision of performance control chart for Shift A and constructed to find the percentage of performance pattern. Average value is 0.8611, UCL and LCL value is varying because the n value is variable.

Table 4.11: 2nd revised control chart data for Performance in shift A

DAY	NET OPERATION TIME (np)	OPERATION TIME (n)	PERFORMANCE (p)	CENTER P BAR	UCL	LCL	SIGMA P BAR	Z
7	409	474	0.863	0.8611	0.9088	0.8134	0.0159	3
22	409	474	0.863	0.8611	0.9088	0.8134	0.0159	3
23	402	474	0.848	0.8611	0.9088	0.8134	0.0159	3
24	402	472	0.852	0.8611	0.9089	0.8133	0.0159	3
28	402	474	0.848	0.8611	0.9088	0.8134	0.0159	3
29	402	474	0.848	0.8611	0.9088	0.8134	0.0159	3
30	395	465	0.849	0.8611	0.9092	0.8130	0.0160	3
5	474	534	0.888	0.8611	0.9060	0.8162	0.0150	3
20	422	474	0.890	0.8611	0.9088	0.8134	0.0159	3
3-Sep-15	452	523	0.864	0.8611	0.9065	0.8157	0.0151	3
10	395	466	0.848	0.8611	0.9092	0.8130	0.0160	3
14	409	479	0.854	0.8611	0.9085	0.8137	0.0158	3
17	401	471	0.851	0.8611	0.9089	0.8133	0.0159	3
28-Sep	416	470	0.885	0.8611	0.9090	0.8132	0.0160	3
	5790	6724	0.8611					

$$\bar{p} = \frac{5790}{6724}$$

$$= 0.8611$$

$$UCL_p = 0.8611 + 3\sqrt{\frac{0.8611\,(1-0.8611)}{474}}$$

$$= 0.9088$$

$$LCL_p = 0.8611 - 3\sqrt{\frac{0.8611\,(1-0.8611)}{474}}$$

$$= 0.8134$$

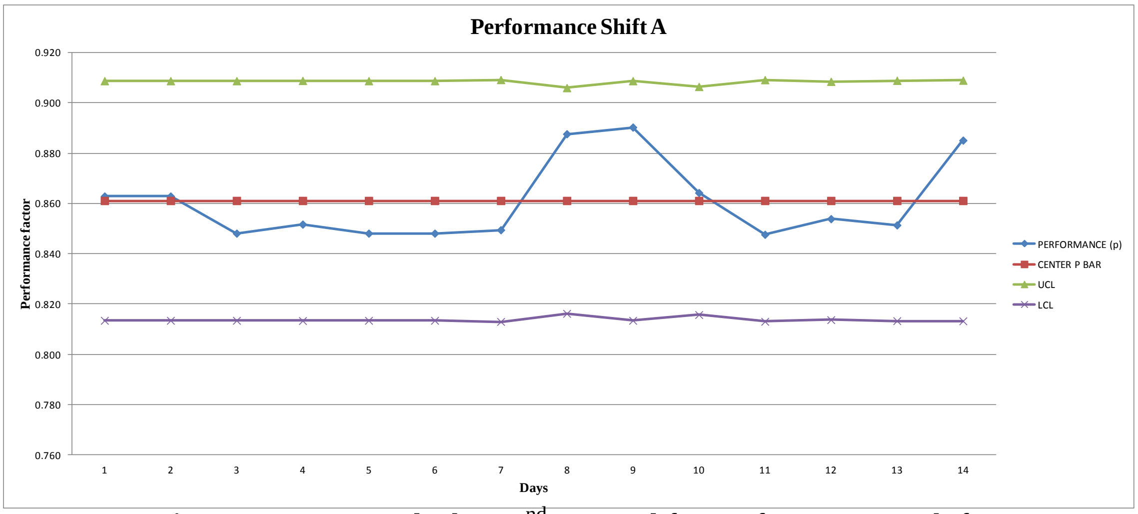

Figure 4.21: Control Chart 2^{nd} Revised for Performance in Shift A

4.4.2.2 Shift B

Figure 4.22 shows the second revision of performance control chart for Shift B and constructed to find the percentage of performance pattern. Average value is 0.9497, UCL and LCL value is varying because the n value is variable.

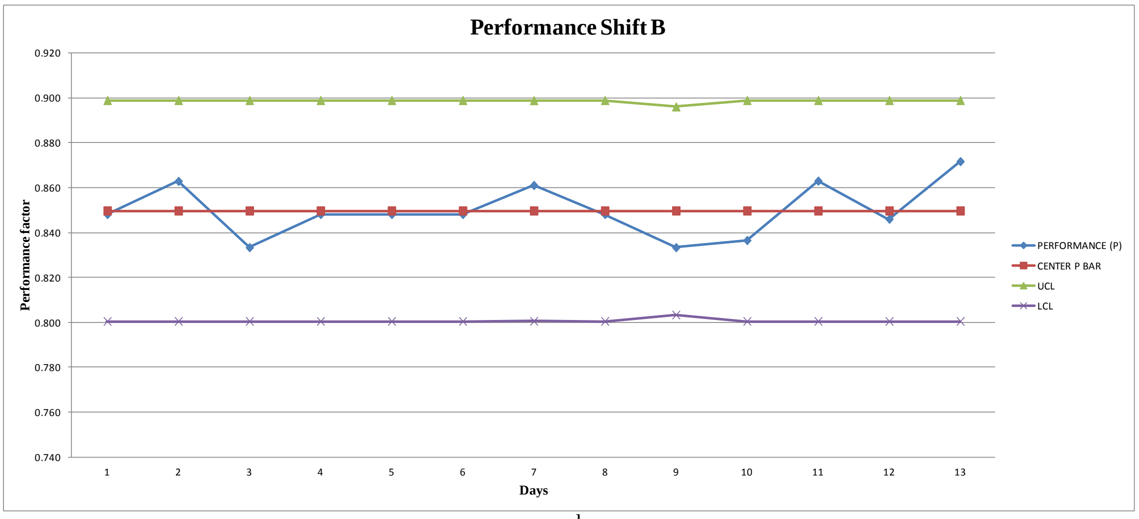

Figure 4.22: Control Chart 2^{nd} Revised for Performance in Shift B

4.4.3.3 Quality

4.4.3.3.1 Shift A

Table 4.12 shows the data after eliminated the below point of central line to get a stable control chart. Below shows the establish central line and control limits for 2nd revised. Figure 4.23 shows the second revision of quality control chart for Shift A and constructed to find the percentage of quality pattern. Average value is 0.9797, UCL and LCL value is varying because the n value is variable.

Table 4.12: 2nd revised control chart data for Quality in shift A

DAY	OK PRODUCT PER SHIFT (np)	TOTAL OUTPUT PER SHIFT (n)	QUALITY (p)	CENTER (P-BAR)	UCL	LCL	SIGMA P-BAR	Z
1-Jul-15	53	55	0.9636	0.9797	1.0367	0.9227	0.0190	3
2	54	55	0.9818	0.9797	1.0367	0.9227	0.0190	3
3	50	50	1.0000	0.9797	1.0395	0.9199	0.0199	3
6	58	60	0.9667	0.9797	1.0343	0.9251	0.0182	3
7	56	57	0.9825	0.9797	1.0357	0.9237	0.0187	3
10	48	50	0.9600	0.9797	1.0395	0.9199	0.0199	3
11	50	52	0.9615	0.9797	1.0384	0.9210	0.0196	3
13	53	53	1.0000	0.9797	1.0378	0.9216	0.0194	3
14	54	55	0.9818	0.9797	1.0367	0.9227	0.0190	3
22	55	57	0.9649	0.9797	1.0357	0.9237	0.0187	3
23	54	56	0.9643	0.9797	1.0362	0.9232	0.0188	3
24	55	56	0.9821	0.9797	1.0362	0.9232	0.0188	3
27	52	52	1.0000	0.9797	1.0384	0.9210	0.0196	3
28	56	56	1.0000	0.9797	1.0362	0.9232	0.0188	3
29	54	56	0.9643	0.9797	1.0362	0.9232	0.0188	3
30	54	55	0.9818	0.9797	1.0367	0.9227	0.0190	3
3-Aug-15	68	70	0.9714	0.9797	1.0303	0.9291	0.0169	3
4	57	58	0.9828	0.9797	1.0353	0.9241	0.0185	3
5	64	66	0.9697	0.9797	1.0318	0.9276	0.0174	3
6	61	62	0.9839	0.9797	1.0334	0.9260	0.0179	3
18	48	50	0.9600	0.9797	1.0395	0.9199	0.0199	3
22	64	66	0.9697	0.9797	1.0318	0.9276	0.0174	3
24	61	63	0.9683	0.9797	1.0330	0.9264	0.0178	3
25	59	61	0.9672	0.9797	1.0339	0.9255	0.0181	3
3-Sep-15	62	63	0.9841	0.9797	1.0330	0.9264	0.0178	3
10	55	55	1.0000	0.9797	1.0367	0.9227	0.0190	3
11	46	46	1.0000	0.9797	1.0421	0.9173	0.0208	3
12	61	61	1.0000	0.9797	1.0339	0.9255	0.0181	3
14	57	57	1.0000	0.9797	1.0357	0.9237	0.0187	3
22	55	57	0.9649	0.9797	1.0357	0.9237	0.0187	3
29	60	60	1.0000	0.9797	1.0343	0.9251	0.0182	3
	1734	1770	0.9797					

$$\bar{p} = \frac{1734}{1770}$$

$$= 0.9797$$

$$UCL_p = 0.9797 + 3\sqrt{\frac{0.9797\,(1-0.9797)}{55}}$$

$$= 1.0367$$

$$LCL_p = 0.9797 - 3\sqrt{\frac{0.9797\,(1-0.9797)}{55}}$$

$$= 0.9227$$

Figure 4.23: Control Chart 2nd Revised for Quality in Shift A

4.4.3.3.2 Shift B

Figure 4.24 shows the second revision of quality control chart for Shift B and constructed to find the percentage of quality pattern. Average value is 0.9922, UCL and LCL value is varying because the n value is variable.

Figure 4.24: Control Chart 2nd Revised for Quality in Shift B

4.4.4 Comparisons between the existing OEE with 1st and 2nd revised OEE and world class OEE in each shift

Figure 4.25 shown the comparison of existing, 1st revised and 2nd revised OEE with world class OEE.OEE value improved by 0.0089% after 1st revised with existing OEE value. 2nd revised improved by 0.0458% with existing OEE value.

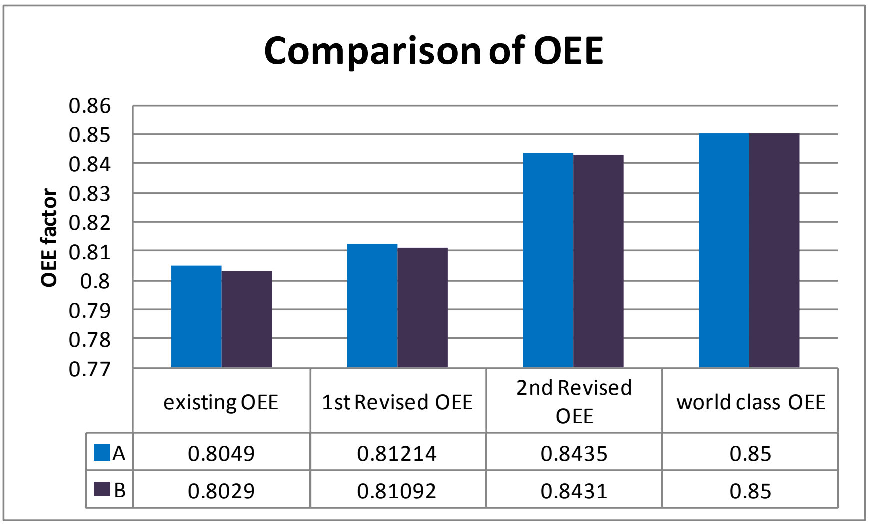

Figure 4.25: the comparisons between the existing OEE with 1st and 2nd revised OEE and world class OEE in each shift

4.4.5 Pareto diagram

Through production data, the downtime rate is analyzed and categorized into 8 types of causes. Table 4.13 below shows the downtime causes including machine breakdown (A), logistics (B), waiting hanger (C), process quality issue (D), operator downstation (E), others (F), and vehicle quality issue (G).

Table 4.13: Downtime Causes Calculation

issue	frequent	cumulative frequency	cumulative %
machine breakdown	896	896	59.46
logistics	222	1118	74.19
waiting hanger	217	1335	88.59
process quality issue	95	1430	94.89
operator downstation	32	1462	97.01
others	28	1490	98.87
vehicle quality issue	17	1507	100.00

The Pareto Chart shows the relative frequency of issues in rank-order. Figure 4.26 shows is a Pareto chart of issues due to line stoppage in Chassis-Final Assembly line. It shows that machine breakdown has the higher frequency issues on line stoppage.

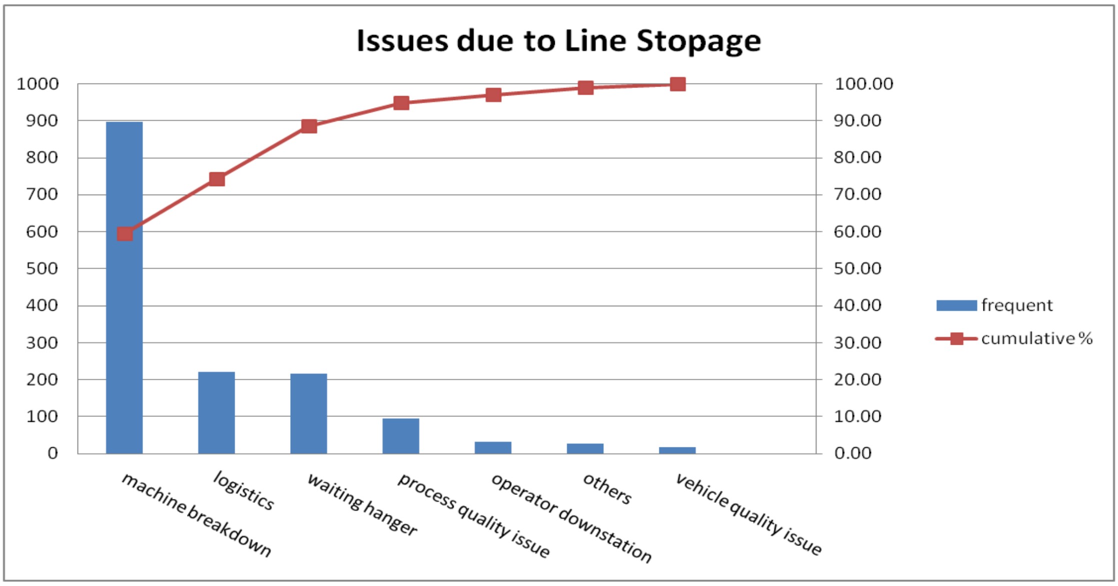

Figure 4.26: Pareto Chart

4.4.6 Ishikawa Diagram

Ishikawa diagram is used to identify the root cause of high downtime losses. Figure 4.27 shows the Ishikawa diagram to analyze why downtime rate is higher. There are five major possibilities that lead to this problem. There are machine, man, method, materials, and environment.

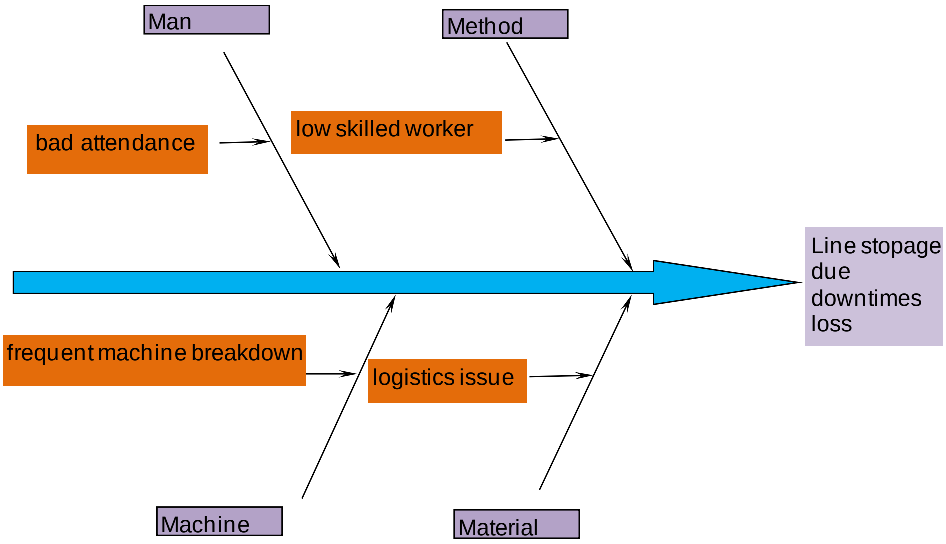

Figure 4.27: Ishikawa Diagram

4.4.6.1 Man

- Bad attendance
  This factor mostly happens to Malaysian citizen, they came to work not every day. They left the workstation without support operator and this cause machine cannot run properly. This is indicated at 1st July 2015 for 55 times.

4.4.6.2 Method

- Low skilled operator
  This happen only to new operator. They handling the machine without supervised from the leader and cannot understand the language used. This situation can be eliminate by sent them to training in the company.

4.4.6.3 Machine

- Frequent machine breakdown

Door manipulator cannot push up and down .This failure cause by hose leaking for about 12 times. This factor can be control by check, repair and properly layout air hose in the line. Air leak tester indicate NG reading. This failure cause by hose bend for about 9 times. This factor can be reduced by check, repair and properly layout air hose in the line. This factor indicated on 11 July 2015 for 62 times.

4.4.6.4 Material

- Logistics issue
  Order from customer changing, and the changeover process delaying the process flow in the Chassis final Assembly Line. It also connected to logistics department to supply the parts from logistics department. This indicated on 1st July 2015 for 63 times.

4.4.7 Improvement using 5W1H Method

From the Table 4.6 above, the problems are identified. 5W1H method was used to improve problems happened Chassis Final Assembly Line. The information are gathered through What, Why, When, Who, Where and How question. For the first 5W is used to specify more details on the root cause while 1H is used to propose a solution to eliminate or reduce the problem. It will be shown in Table 4.7.

Table 4.14: 5W1H Method

Question	Answer
Problem	Downtime loss
What?	Frequent machine breakdown due to line stoppages
Who?	Maintenance teams and operator
When?	Almost everyday
Where?	Chassis-Final Assembly Line
Why?	There is no preventive maintenance work performed in Chassis-Final Assembly Line because there is no proper schedule for preventive maintenance. TCMA practice reactive maintenance where they only fix the machine when breakdown happen.
How?	Implementation and monitor of Planned Scheduled Maintenance for the machines to reduce the downtime rate in Chassis-Final Assembly Line so that the parts and supplies can be ready to go.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter, the conclusion will be based on research done in previous chapters. There are also a few recommendations given to strengthen and improve the performance of the production system in TCMA Chassis-Final Assembly Line .

5.2 CONCLUSION

As a conclusion, the value of OEE can be measured by finding the three elements of OEE itself; availability, performance and quality. These three elements must be balance with each other in order to get stable value of OEE. In this study, Chassis-Final Assembly Line section was chosen because the higher downtime rate and solution is needed to solve the problem. Results from the existing graph collected from company was out of control and below World Class OEE benchmarking, because there are some point that out of control limit and there is out of control patterns exist.

Analyzing was done by revised the existing control chart by eliminate the point that out of control by calculating the existing OEE value to see if there any improvement. OEE value could be improved from 80.49% to 81.21%, and 80.29% to 81.09% for A, and B shift respectively. 2nd revised was done by eliminating the point which below control limit and taking the best point between central limit and upper control limit and calculating based on the best point and OEE value can improved from 81.21% to 84.35%, and 81.09% to 84.31%, for A, and B shift respectively. This shown that 2nd revised OEE value nearly to World Class Ranking about 0.65% and 0.69% for shift A and B respectively. This is possible to improve the OEE value by eliminating the problem occurred on Pareto Diagram such as machine breakdown, logistics issues and waiting hanger.. Based on the problem occurred, there are causes affecting the problem in Ishikawa Diagram such as Bad attendance, low skilled worker and frequent machine breakdown. From this problem and causes it was proposed in 5W1H method to find the solution as shown in below.

5.3 RECOMMENDATIONS

There is always space for improvement for every completed studies and research. As in the future, there are several recommendations to be proposed for making an improvement. An improvement can be proposed from 5W1H method that has been done in previous chapter. To eliminate the problem occurred in Chassis final Assembly line, TCMA should implemented and monitor of Planned Scheduled Maintenance to decrease the downtime rate, so that the part and supplies can be ready to go in order to prevent zero spare parts of machine components. Scheduled maintenance tasks should be performed based on predicted and measured failure rates in previous history. Consequently, it will reduce the instances of unplanned downtime and enables most maintenance to be planned for times when equipment is not scheduled for production. It will also reduce inventory through better control of wear-prone and failure-prone parts.

The suggested future OEE value for this company is 84.35%, and 84.31% for, A, and B shift respectively. Since these values are calculated based on the existing value of OEE elements in this company, hence it means that it is a possible for them to achieve this target OEE in the future if suggestions and methods analyzed are implemented for continuous improvement.

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APPENDIX A
A1: GANTT CHART

	FYP 1	**SEPT**			**OCT**					**NOV**				**DEC**	
No.	**Project Activities**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
1	Identify suitable company for project														
2	Study the current maintenance system														
3	Verify the project title														
4	Drafting Chapter 1: Introduction														
5	Finalize and Submit draft Chapter 1														
6	Drafting Chapter 2: Literature Review														
7	Finalize and Submit draft Chapter 2														
8	Verify suitable selection method														
9	Drafting Chapter 3: Methodology														
10	Finalize and Submit Draft Chapter 3														
11	Compile and Submit Chapter 1, 2, and 3														
12	Prepare for final presentation														
13	FYP 1 Final Presentation														

A2: GANTT CHART (Continued)

	FYP 2	FEB	MAR				APR					MAY			
No.	**Project Activities**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
1	Data collection and analyze data														
2	Drafting Chapter 4: Results and Discussions														
3	Finalize and Submit Draft Chapter 4														
4	Drafting Chapter 5: Conclusions and Recommendations														
5	Finalize and Submit Draft Chapter 5														
6	Prepare Poster														
7	Poster Presentation														
8	Compiling Chapter 1, 2, 3, 4, and 5														
9	Submit Final Report														

Remarks: Planned progress Actual progress

APPENDIX B

B1: Chassis-Final Assembly Line Production Data for July 2015

Shift A

No.	CHASSIS-FINAL LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Cumul.
1	Planned downtime per Shift	71	71	71	0	0	71	71	71	71	71	71	0	71	71	0	0	0	0	0	0		71	71	71	0	0	71	71	71	71	71	1349
2A	Downtime Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	11	0	0	9	0	22
	- Machine breakdown (G)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	11	0	0	9	0	22
	- Tools / Jig (J)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Vehicle quality issue (I)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	0	0	0	0	0	0	10	0	0	7	28	0	0	16	0	0	0	0	0	0	0	15	5	0	0	0	0	32	19	0	0	132
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Operator downstation (P)	23	16	0	0	0	19	5	5	0	2	0	0	0	20	0	0	0	0	0	0	0	21	0	2	0	0	10	16	18	16	57	230
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	0	0	0	0	0	0	44	0	0	27	16	0	0	0	0	0	0	0	0	0	0	0	51	0	0	0	0	20	3	2	0	163
	- Others (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Offline Unit per day	2	1	0	0	0	2	1	6	3	2	2	0	0	1	0	0	0	0	0	0	0	2	2	1	0	0	0	0	2	1	0	28
4	Total operating hours per Shift	545	545	545	0	0	545	545	545	545	545	545	0	545	545	0	0	0	0	0	0		545	545	545	0	0	545	545	545	545	545	10355
5	Planned Production Time = (4) - (1)	474	474	474	0	0	474	474	474	474	474	474	0	474	474	0	0	0	0	0	0	0	474	474	474	0	0	474	474	474	474	474	9006
6	Operation Time = (5) - (2A) - (2B)	474	474	474	0	0	474	474	474	474	474	474	0	474	474	0	0	0	0	0	0	0	474	474	472	0	0	463	474	474	465	474	8984
7	Total Output Per Shift	55	55	50	0	0	60	57	63	50	50	52	0	53	55	0	0	0	0	0	0	0	57	56	56	0	0	52	56	56	55	50	1038
8	OK Product per Shift = (7) - (3)	53	54	50	0	0	58	56	57	47	48	50	0	53	54	0	0	0	0	0	0	0	55	54	55	0	0	52	56	54	54	50	1010
9	Actual cycle time	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18
10	Net Operation Time = (7) x (9)	395	395	359	0	0	431	409	452	359	359	373	0	381	395	0	0	0	0	0	0	0	409	402	402	0	0	373	402	402	395	359	7453
11	Availability (%) = (6) / (5) x 100%	100.0	100.0	100.0	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	100.0	#DIV/0!	100.0	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	100.0	100.0	99.6	#DIV/0!	#DIV/0!	97.7	100.0	100.0	98.1	100.0	99.8
12	Performance (%) = (10) / (6) x 100%	83.3	83.3	75.7	#DIV/0!	#DIV/0!	90.9	86.3	95.4	75.7	75.7	78.8	#DIV/0!	80.3	83.3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	86.3	84.8	85.2	#DIV/0!	#DIV/0!	80.6	84.8	84.8	84.9	75.7	83.0
13	Quality (%) = (8) / (7) x 100%	96.4	98.2	100.0	#DIV/0!	#DIV/0!	96.7	98.2	90.5	94.0	96.0	96.2	#DIV/0!	100.0	98.2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	96.5	96.4	98.2	#DIV/0!	#DIV/0!	100.0	100.0	96.4	98.2	100.0	97.3
14	Overall Equipment Effectiveness (OEE) %	80.3	81.8	75.7	#DIV/0!	#DIV/0!	87.9	84.8	86.3	71.2	72.7	75.7	#DIV/0!	80.3	81.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	83.3	81.8	83.3	#DIV/0!	#DIV/0!	78.8	84.8	81.8	81.8	75.7	80.5

Shift B

No.	CHASSIS-FINAL LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Cumul.
1	Planned downtime per Shift	71	71	71	0	0	71	71	71	71	71	71	0	71	71	0	0	0	0	0	0	0	71	71	71	0	0	71	71	71	71	71	1349
2A	Downtime Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Machine breakdown (G)	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Tools / Jig (J)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Vehicle quality issue (I)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	0	0	0	0	0	18	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Operator downstation (P)	0	5	30	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	39	17	0	0	0	15	0	50	0	127	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0
	- Others (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Offline Unit per day	0	2	1	0	0	2	2	4	2	1	2	0	2	2	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	2	27
4	Total operating hours per Shift	545	545	545	0	0	545	545	545	545	545	545	0	545	545	0	0	0	0	0	0		545	545	545	0	0	545	545	545	546	547	10358
5	Planned Production Time = (4) - (1)	474	474	474	0	0	474	474	474	474	474	474	0	474	474	0	0	0	0	0	0	0	474	474	474	0	0	474	474	474	475	476	9009
6	Operation Time = (5) - (2A) - (2B)	474	474	474	0	0	474	474	474	474	474	474	0	474	474	0	0	0	0	0	0	0	474	474	474	0	0	474	474	474	475	476	9009
7	Total Output Per Shift	56	53	57	0	0	61	60	60	55	51	50	0	56	52	0	0	0	0	0	0	0	56	50	51	0	0	56	50	50	50	51	1025
8	OK Product per Shift = (7) - (3)	56	51	56	0	0	59	58	56	53	50	48	0	54	50	0	0	0	0	0	0	0	54	50	51	0	0	56	47	50	50	49	998
9	Actual cycle time	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	8.18	9.18	7.28
10	Net Operation Time = (7) x (9)	402	381	409	0	0	438	431	431	395	366	359	0	402	373	0	0	0	0	0	0	0	402	359	366	0	0	402	359	359	409	468	7512
11	Availability (%) = (6) / (5) x 100%	100.0	100.0	100.0	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	100.0	#DIV/0!	100.0	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	100.0	100.0	100.0	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	100.0
12	Performance (%) = (10) / (6) x 100%	84.8	80.3	86.3	#DIV/0!	#DIV/0!	92.4	90.9	90.9	83.3	77.3	75.7	#DIV/0!	84.8	78.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	84.8	75.7	77.3	#DIV/0!	#DIV/0!	84.8	75.7	75.7	86.1	98.4	83.4
13	Quality (%) = (8) / (7) x 100%	100.0	96.2	98.2	#DIV/0!	#DIV/0!	96.7	96.7	93.3	96.4	98.0	96.0	#DIV/0!	96.4	96.2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	96.4	100.0	100.0	#DIV/0!	#DIV/0!	100.0	94.0	100.0	100.0	96.1	97.4
14	Overall Equipment Effectiveness (OEE) %	84.8	77.3	84.8	#DIV/0!	#DIV/0!	89.4	87.9	84.8	80.3	75.7	72.7	#DIV/0!	81.8	75.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	81.8	75.7	77.3	#DIV/0!	#DIV/0!	84.8	71.2	75.7	86.1	94.5	81.2

B2: Chassis-Final Assembly Line Production Data for August 2015

Shift A

No.	CHASSIS-FINAL LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Cumul.
1	Planned downtime per Shift	0	0	71	71	71	71	71	0	0	71	71	71	71	126	71	0	71	71	71	71	71	71	0	71	71	71	71	0	0	0	0	1546
2A	Downtime Loss	0	0	0	0	0	0	0	0	0	26	62	0	0	0	0	0	39	9	0	0	0	0	0	0	37	0	0	0	0	0	0	173
	- Machine breakdown (G)	0	0	0	0	0	0	0	0	0	26	62	0	0	0	0	0	39	9	0	0	0	0	0	0	37	0	0	0	0	0	0	173
	- Tools / Jig (J)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	3	0	4	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
	- Vehicle quality issue (I)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	0	0	18	5	14	0	0	0	0	7	0	7	18	0	13	0	0	0	8	0	5	16	0	35	0	9	0	0	0	0	0	155
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Operator downstation (P)	0	0	2	15	8	3	46	0	0	5	7	6	26	9	20	0	21	4	8	6	12	4	0	2	24	36	0	0	0	0	0	264
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	0	0	0	22	4	11	0	0	0	26	0	0	0	0	27	0	7	58	22	15	0	22	0	2	4	0	0	0	0	0	0	220
	- Others (B)	0	0	0	5	0	0	2	0	0	0	0	0	0	0	0	0	8	11	7	6	0	0	0	11	2	0	0	0	0	0	0	52
3	Offline Unit per day	0	0	2	1	2	1	4	0	0	3	2	5	4	4	5	0	6	2	3	3	4	2	0	2	2	3	5	0	0	0	0	65
4	Total operating hours per Shift	0	0	605	605	605	605	545	0	0	545	545	545	545	555	545	0	545	605	605	545	605	545	0	545	545	545	545	0	0	0	0	11875
5	Planned Production Time = (4) - (1)	0	0	534	534	534	534	474	0	0	474	474	474	474	429	474	0	474	534	534	474	534	474	0	474	474	474	474	0	0	0	0	10329
6	Operation Time = (5) - (2A) - (2B)	0	0	534	534	534	534	474	0	0	448	412	474	474	429	474	0	435	525	534	474	534	474	0	474	437	474	474	0	0	0	0	10156
7	Total Output Per Shift	0	0	70	58	66	62	62	0	0	52	63	71	64	66	50	0	58	50	56	60	70	66	0	63	61	65	50	0	0	0	0	1283
8	OK Product per Shift = (7) - (3)	0	0	68	57	64	61	58	0	0	49	61	66	60	62	45	0	52	48	53	57	66	64	0	61	59	62	45	0	0	0	0	1218
9	Actual cycle time	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.18	7.18	7.18	7.18	7.13
10	Net Operation Time = (7) x (9)	0	0	503	416	474	445	445	0	0	373	452	510	460	474	359	0	408	352	394	422	493	465	0	444	429	458	352	0	0	0	0	9128
11	Availability (%) = (6) / (5) x 100%	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	#DIV/0!	#DIV/0!	94.5	86.9	100.0	100.0	100.0	100.0	#DIV/0!	91.8	98.3	100.0	100.0	100.0	100.0	#DIV/0!	100.0	92.2	100.0	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	98.3
12	Performance (%) = (10) / (6) x 100%	#DIV/0!	#DIV/0!	94.1	78.0	88.7	83.4	93.9	#DIV/0!	#DIV/0!	83.3	109.8	107.5	96.9	110.5	75.7	#DIV/0!	93.9	67.0	73.8	89.1	92.3	98.0	#DIV/0!	93.6	98.3	96.5	74.3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	89.9
13	Quality (%) = (8) / (7) x 100%	#DIV/0!	#DIV/0!	97.1	98.3	97.0	98.4	93.5	#DIV/0!	#DIV/0!	94.2	96.8	93.0	93.8	93.9	90.0	#DIV/0!	89.7	96.0	94.6	95.0	94.3	97.0	#DIV/0!	96.8	96.7	95.4	90.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	94.9
14	Overall Equipment Effectiveness (OEE) %	#DIV/0!	#DIV/0!	91.4	76.6	86.1	82.0	87.9	#DIV/0!	#DIV/0!	74.2	92.4	100.0	90.9	103.8	68.2	#DIV/0!	77.2	63.3	69.9	84.7	87.0	95.1	#DIV/0!	90.6	87.6	92.1	66.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	83.9

Shift B

No.	CHASSIS-FINAL LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Cumul.
1	Planned downtime per Shift	0	0	71	71	71	71	126	0	0	71	89	71	71	71	71	0	71	71	71	71	126	71	0	71	71	71	71	0	0	0	0	1619
2A	Downtime Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Machine breakdown (G)	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Tools / Jig (J)	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
	- Vehicle quality issue (I)	0	0	0	0	0	0	0	0	0	5	0	0	11	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	7	15	15	0	0	0	0	0	0
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	6	75	0	0	0	0	0	0	0	0	0	0	0	0	5	11	0	18	0	0	0	0	0
	- Operator downstation (P)	0	0	0	20	12	0	0	0	0	18	10	19	22	0	8	0	0	0	6	0	28	22	0	18	11	3	41	0	0	0	0	0
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	0	0	0	6	11	0	0	0	0	3	0	0	0	0	0	0	138	0	103	70	26	5	0	0	0	0	0	0	0	0	0	0
	- Others (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Offline Unit per day	0	0	2	1	2	1	3	0	0	2	2	1	2	2	1	0	1	2	1	3	1	2	0	2	2	1	3	0	0	0	0	37
4	Total operating hours per Shift	0	0	605	545	605	605	615	0	0	605	665	545	545	605	545	0	545	605	605	545	615	545	0	545	545	545	545	0	0	0	0	12125
5	Planned Production Time = (4) - (1)	0	0	534	474	534	534	489	0	0	534	576	474	474	534	474	0	474	534	534	474	489	474	0	474	474	474	474	0	0	0	0	10506
6	Operation Time = (5) - (2A) - (2B)	0	0	534	474	534	534	489	0	0	534	576	474	474	534	474	0	474	534	534	474	489	474	0	474	474	474	474	0	0	0	0	10506
7	Total Output Per Shift	0	0	70	56	60	62	61	0	0	53	64	71	66	67	50	0	38	48	48	60	57	54	0	67	67	70	53	0	0	0	0	1242
8	OK Product per Shift = (7) - (3)	0	0	68	55	58	61	58	0	0	51	62	70	64	65	49	0	37	46	47	57	56	52	0	65	65	69	50	0	0	0	0	1205
9	Actual cycle time	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.11
10	Net Operation Time = (7) x (9)	0	0	503	402	431	445	438	0	0	381	460	510	474	481	359	0	268	338	338	422	401	380	0	472	472	493	373	0	0	0	0	8839
11	Availability (%) = (6) / (5) x 100%	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	100.0	#DIV/0!	100.0	100.0	100.0	100.0	100.0	100.0	#DIV/0!	100.0	100.0	100.0	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	100.0
12	Performance (%) = (10) / (6) x 100%	#DIV/0!	#DIV/0!	94.1	84.8	80.7	83.4	89.6	#DIV/0!	#DIV/0!	71.3	79.8	107.5	100.0	90.1	75.7	#DIV/0!	56.4	63.3	63.3	89.1	82.1	80.2	#DIV/0!	99.5	99.5	104.0	78.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	84.1
13	Quality (%) = (8) / (7) x 100%	#DIV/0!	#DIV/0!	97.1	98.2	96.7	98.4	95.1	#DIV/0!	#DIV/0!	96.2	96.9	98.6	97.0	97.0	98.0	#DIV/0!	97.4	95.8	97.9	95.0	98.2	96.3	#DIV/0!	97.0	97.0	98.6	94.3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	97.0
14	Overall Equipment Effectiveness (OEE) %	#DIV/0!	#DIV/0!	91.4	83.3	78.0	82.0	85.2	#DIV/0!	#DIV/0!	68.6	77.3	106.0	96.9	87.4	74.2	#DIV/0!	55.0	60.6	62.0	84.7	80.6	77.2	#DIV/0!	96.5	96.5	102.5	74.3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	81.6

B3: Chassis-Final Assembly Line Production Data for September 2015

Shift A

No.	CHASSIS-FINAL LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Planned downtime per Shift	71	71	71	71	0	0	126	0	0	71	89	71	0	71	71
2A	Downtime Loss	12	0	11	20	0	0	26	0	0	8	9	0	0	5	0
	- Machine breakdown (G)	12	0	11	20	0	0	26	0	0	8	9	0	0	5	0
	- Tools / Jig (J)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Vehicle quality issue (I)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	63	0	0	49	0	0	3	4	0	8	24	33	0	21	0
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Operator downstation (P)	6	2	0	15	0	0	10	47	33	18	25	10	0	0	13
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	0	0	0	0	0	0	2	0	43	23	4	0	0	21	0
	- Others (B)	0	2	0	0	0	0	11	0	0	4	9	0	0	0	8
3	Offline Unit per day	0	10	1	5	0	0	0	0	6	0	0	0	0	0	0
4	Total operating hours per Shift	0	0	605	605	605	605	545	0	0	545	545	545	545	555	545
5	Planned Production Time = (4) - (1)	-71	-71	534	534	605	605	419	0	0	474	456	474	545	484	474
6	Operation Time = (5) - (2A) - (2B)	-83	-71	523	514	605	605	393	0	0	466	447	474	545	479	474
7	Total Output Per Shift	50	63	63	50	0	0	63	55	51	55	46	61	0	57	67
8	OK Product per Shift = (7) - (3)	50	53	62	45	0	0	63	55	45	55	46	61	0	57	67
9	Actual cycle time	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18
10	Net Operation Time = (7) x (9)	359	452	452	359	0	0	452	395	366	395	330	438	0	409	481
11	Availability (%) = (6) / (5) x 100%	116.9	100.0	97.9	96.3	100.0	100.0	93.8	#DIV/0!	#DIV/0!	98.3	98.0	100.0	100.0	99.0	100.0
12	Performance (%) = (10) / (6) x 100%	-432.5	-637.1	86.5	69.8	0.0	0.0	115.1	#DIV/0!	#DIV/0!	84.7	73.9	92.4	0.0	85.4	101.5
13	Quality (%) = (8) / (7) x 100%	100.0	84.1	98.4	90.0	#DIV/0!	#DIV/0!	100.0	100.0	88.2	100.0	100.0	100.0	#DIV/0!	100.0	100.0
14	Overall Equipment Effectiveness (OEE) %	-505.6	-536.0	83.4	60.5	#DIV/0!	#DIV/0!	108.0	#DIV/0!	#DIV/0!	83.3	72.4	92.4	#DIV/0!	84.6	101.5

No.	CHASSIS-FINAL LINE	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Cumul.
1	Planned downtime per Shift	0	71	71	71	0	126	71	0	0	0	0	0	71	71	71	1406
2A	Downtime Loss	0	3	0	8	0	4	0	0	0	0	0	0	4	14	2	126
	- Machine breakdown (G)	0	3	0	8	0	4	0	0	0	0	0	0	4	14	2	126
	- Tools / Jig (J)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
	- Vehicle quality issue (I)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	0	2	8	7	0	17	0	0	0	0	0	0	40	20	8	307
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Operator downstation (P)	0	27	9	2	0	3	26	38	0	0	0	0	2	0	0	286
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	0	4	0	0	0	0	15	7	0	0	0	0	0	0	0	119
	- Others (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34
3	Offline Unit per day	0	14	6	5	0	6	2	0	0	0	0	0	5	0	6	66
4	Total operating hours per Shift	0	545	605	605	545	605	545	0	0	0	0	0	545	545	545	11330
5	Planned Production Time = (4) - (1)	0	474	534	534	545	479	474	0	0	0	0	0	474	474	474	9924
6	Operation Time = (5) - (2A) - (2B)	0	471	534	526	545	475	474	0	0	0	0	0	470	460	472	9798
7	Total Output Per Shift	0	57	70	71	0	61	57	60	0	0	0	0	58	60	41	1216
8	OK Product per Shift = (7) - (3)	0	43	64	66	0	55	55	60	0	0	0	0	53	60	35	1150
9	Actual cycle time	7.18	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.18	7.18	7.18	7.13
10	Net Operation Time = (7) x (9)	0	401	493	500	0	429	401	422	0	0	0	0	416	431	294	8678
11	Availability (%) = (6) / (5) x 100%	#DIV/0!	99.4	100.0	98.5	100.0	99.2	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	99.2	97.0	99.6	98.7
12	Performance (%) = (10) / (6) x 100%	#DIV/0!	85.2	92.3	95.0	0.0	90.4	84.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	88.6	93.7	62.4	88.6
13	Quality (%) = (8) / (7) x 100%	#DIV/0!	75.4	91.4	93.0	#DIV/0!	90.2	96.5	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	91.4	100.0	85.4	94.6
14	Overall Equipment Effectiveness (OEE) %	#DIV/0!	63.9	84.4	87.0	#DIV/0!	80.8	81.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	80.3	90.9	53.0	82.7

Shift B

No.	CHASSIS-FINAL LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Planned downtime per Shift	71	71	71	71	0	0	126	0	0	71	89	71	0	71	71
2A	Downtime Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Machine breakdown (G)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Tools / Jig (J)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Vehicle quality issue (I)	22	0	0	0	0	0	0	0	13	8	0	5	0	22	55
	- Logistics (D)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- PPC (H)	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Chassis jammed (C)	0	47	0	0	0	0	0	0	4	0	0	0	0	0	0
	- Operator downstation (P)	0	15	4	0	0	0	0	0	2	38	10	0	0	0	14
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	55	0	0	0	0	0	18	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	10	0	28	0	0	0	0	33	45	6	7	15	0	7	31
	- Others (B)	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0
3	Offline Unit per day	0	0	0	3	0	0	0	0	1	1	0	1	0	0	0
4	Total operating hours per Shift	545	545	605	545	0	0	615	545	545	605	665	545	0	605	545
5	Planned Production Time = (4) - (1)	474	474	534	474	0	0	489	545	545	534	576	474	0	534	474
6	Operation Time = (5) - (2A) - (2B)	474	474	534	474	0	0	489	545	545	534	576	474	0	534	474
7	Total Output Per Shift	48	52	57	60	0	0	71	61	52	56	60	62	0	67	44
8	OK Product per Shift = (7) - (3)	48	52	57	57	0	0	71	61	51	55	60	61	0	67	44
9	Actual cycle time	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18
10	Net Operation Time = (7) x (9)	345	373	409	431	0	0	510	438	373	402	431	445	0	481	316
11	Availability (%) = (6) / (5) x 100%	100.0	100.0	100.0	100.0	#DIV/0!	#DIV/0!	100.0	100.0	100.0	100.0	100.0	100.0	#DIV/0!	100.0	100.0
12	Performance (%) = (10) / (6) x 100%	72.7	78.8	76.6	90.9	#DIV/0!	#DIV/0!	104.2	80.4	68.5	75.3	74.8	93.9	#DIV/0!	90.1	66.6
13	Quality (%) = (8) / (7) x 100%	100.0	100.0	100.0	95.0	#DIV/0!	#DIV/0!	100.0	100.0	98.1	98.2	100.0	98.4	#DIV/0!	100.0	100.0
14	Overall Equipment Effectiveness (OEE) %	72.7	78.8	76.6	86.3	#DIV/0!	#DIV/0!	104.2	80.4	67.2	74.0	74.8	92.4	#DIV/0!	90.1	66.6

No.	CHASSIS-FINAL LINE	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Cumul.
1	Planned downtime per Shift	0	71	71	71	0	126	71	0	0	0	0	0	71	71	71	1406
2A	Downtime Loss	0	3	0	0	0	0	0	0	0	0	0	0	22	0	0	25
	- Machine breakdown (G)	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0
	- Tools / Jig (J)	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	Speed Loss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Process quality issue (Q)	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0
	- Vehicle quality issue (I)	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Logistics (D)	0	0	0	0	0	0	0	0	0	0	0	0	0	17	13	0
	- PPC (H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Chassis jammed (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Operator downstation (P)	0	2	0	0	0	0	0	0	0	0	0	0	8	0	12	0
	- New operator under training (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Bad attendance (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Waiting hanger (W)	0	46	0	0	0	0	0	0	0	0	0	0	0	42	12	0
	- Others (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0
3	Offline Unit per day	0	2	0	0	0	0	0	0	0	0	0	0	11	0	2	21
4	Total operating hours per Shift	0	545	605	605	0	615	545	0	0	0	0	0	545	545	545	11460
5	Planned Production Time = (4) - (1)	0	474	534	534	0	489	474	0	0	0	0	0	474	474	474	10054
6	Operation Time = (5) - (2A) - (2B)	0	471	534	534	0	489	474	0	0	0	0	0	452	474	474	10029
7	Total Output Per Shift	0	56	44	70	0	60	57	0	0	0	0	0	56	50	61	1144
8	OK Product per Shift = (7) - (3)	0	54	44	70	0	60	57	0	0	0	0	0	45	50	59	1123
9	Actual cycle time	7.18	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.11
10	Net Operation Time = (7) x (9)	0	394	310	493	0	422	401	0	0	0	0	0	394	352	429	8150
11	Availability (%) = (6) / (5) x 100%	#DIV/0!	99.4	100.0	100.0	#DIV/0!	100.0	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	95.4	100.0	100.0	99.8
12	Performance (%) = (10) / (6) x 100%	#DIV/0!	83.7	58.0	92.3	#DIV/0!	86.4	84.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	87.2	74.3	90.6	81.3
13	Quality (%) = (8) / (7) x 100%	#DIV/0!	96.4	100.0	100.0	#DIV/0!	100.0	100.0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	80.4	100.0	96.7	98.2
14	Overall Equipment Effectiveness (OEE) %	#DIV/0!	80.2	58.0	92.3	#DIV/0!	86.4	84.7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	66.8	74.3	87.6	79.6

APPENDIX C

C1: Control Chart Data for Availability by Shifts

shift A

	DAY	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL
july	1	1	0.9909	1.003985	0.977815
	2	1	0.9909	1.003985	0.977815
	3	1	0.9909	1.003985	0.977815
	6	1	0.9909	1.003985	0.977815
	7	1	0.9909	1.003985	0.977815
	8	1	0.9909	1.003985	0.977815
	9	1	0.9909	1.003985	0.977815
	10	1	0.9909	1.003985	0.977815
	11	1	0.9909	1.003985	0.977815
	13	1	0.9909	1.003985	0.977815
	14	1	0.9909	1.003985	0.977815
	22	1	0.9909	1.003985	0.977815
	23	1	0.9909	1.003985	0.977815
	24	0.995780591	0.9909	1.003985	0.977815
	27	0.976793249	0.9909	1.003985	0.977815
	28	1	0.9909	1.003985	0.977815
	29	1	0.9909	1.003985	0.977815
	30	0.981012658	0.9909	1.003985	0.977815
august	3	1	0.9909	1.003228	0.978572
	4	1	0.9909	1.003228	0.978572
	5	1	0.9909	1.003228	0.978572
	6	1	0.9909	1.003228	0.978572
	7	1	0.9909	1.003985	0.977815
	10	0.945147679	0.9909	1.003985	0.977815
	13	1	0.9909	1.003985	0.977815
	15	1	0.9909	1.003985	0.977815
	17	0.917721519	0.9909	1.003985	0.977815
	18	0.983146067	0.9909	1.003228	0.978572
	19	1	0.9909	1.003228	0.978572
	20	1	0.9909	1.003985	0.977815
	21	1	0.9909	1.003228	0.978572
	22	1	0.9909	1.003985	0.977815
	24	1	0.9909	1.003985	0.977815
	25	0.921940928	0.9909	1.003985	0.977815
	26	1	0.9909	1.003985	0.977815
	27	1	0.9909	1.003985	0.977815
sept	3	0.979400749	0.9909	1.003228	0.978572
	4	0.962546816	0.9909	1.003228	0.978572
	10	0.983122363	0.9909	1.003985	0.977815
	11	0.980263158	0.9909	1.004241	0.977559
	12	1	0.9909	1.003985	0.977815
	14	0.989669421	0.9909	1.003849	0.977951
	17	0.993670886	0.9909	1.003985	0.977815
	18	1	0.9909	1.003228	0.978572
	19	0.985018727	0.9909	1.003228	0.978572
	21	0.991649269	0.9909	1.003916	0.977884
	22	1	0.9909	1.003985	0.977815
	28	0.991561181	0.9909	1.003985	0.977815
	29	0.970464135	0.9909	1.003985	0.977815
	30	0.995780591	0.9909	1.003985	0.977815

shift B

	DAY	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL
july	1	1	0.999	1.003355	0.994645
	2	1	0.999	1.003355	0.994645
	3	1	0.999	1.003355	0.994645
	6	1	0.999	1.003355	0.994645
	7	1	0.999	1.003355	0.994645
	8	1	0.999	1.003355	0.994645
	9	1	0.999	1.003355	0.994645
	10	1	0.999	1.003355	0.994645
	11	1	0.999	1.003355	0.994645
	13	1	0.999	1.003355	0.994645
	14	1	0.999	1.003355	0.994645
	22	1	0.999	1.003355	0.994645
	23	1	0.999	1.003355	0.994645
	24	1	0.999	1.003355	0.994645
	27	1	0.999	1.003355	0.994645
	28	1	0.999	1.003355	0.994645
	29	1	0.999	1.003355	0.994645
	30	1	0.999	1.003351	0.994649
august	3	1	0.999	1.003103	0.994897
	4	1	0.999	1.003355	0.994645
	5	1	0.999	1.003103	0.994897
	6	1	0.999	1.003103	0.994897
	7	1	0.999	1.003288	0.994712
	10	1	0.999	1.003103	0.994897
	11	1	0.999	1.002951	0.995049
	13	1	0.999	1.003355	0.994645
	14	1	0.999	1.003103	0.994897
	15	1	0.999	1.003355	0.994645
	17	1	0.999	1.003355	0.994645
	18	1	0.999	1.003103	0.994897
	18	1	0.999	1.003103	0.994897
	20	1	0.999	1.003355	0.994645
	21	1	0.999	1.003288	0.994712
	22	1	0.999	1.003355	0.994645
	24	1	0.999	1.003355	0.994645
	25	1	0.999	1.003355	0.994645
	26	1	0.999	1.003355	0.994645
	27	1	0.999	1.003355	0.994645
sept	1	1	0.999	1.003355	0.994645
	2	1	0.999	1.003355	0.994645
	3	1	0.999	1.003103	0.994897
	4	1	0.999	1.003355	0.994645
	7	1	0.999	1.003288	0.994712
	8	1	0.999	1.003062	0.994938
	9	1	0.999	1.003062	0.994938
	10	1	0.999	1.003103	0.994897
	11	1	0.999	1.002951	0.995049
	12	1	0.999	1.003355	0.994645
	14	1	0.999	1.003103	0.994897
	15	1	0.999	1.003355	0.994645
	17	0.993670886	0.999	1.003355	0.994645
	18	1	0.999	1.003355	0.994645
	19	1	0.999	1.003355	0.994645
	21	1	0.999	1.003355	0.994645
	22	1	0.999	1.003355	0.994645
	28	0.953586498	0.999	1.003355	0.994645
	29	1	0.999	1.003355	0.994645
	30	1	0.999	1.003355	0.994645

C2: Control Chart Data for Performance by Shifts

shift A					
	DAY	PERFORMANCE (p)	CENTER P BAR	UCL	LCL
july	1	0.833333333	0.8512	0.90024	0.80216
	2	0.833333333	0.8512	0.90024	0.80216
	3	0.757383966	0.8512	0.90024	0.80216
	6	0.9092827	0.8512	0.90024	0.80216
	7	0.862869198	0.8512	0.90024	0.80216
	8	0.953586498	0.8512	0.90024	0.80216
	9	0.757383966	0.8512	0.90024	0.80216
	10	0.757383966	0.8512	0.90024	0.80216
	11	0.786919831	0.8512	0.90024	0.80216
	13	0.803797468	0.8512	0.90024	0.80216
	14	0.833333333	0.8512	0.90024	0.80216
	22	0.862869198	0.8512	0.90024	0.80216
	23	0.848101266	0.8512	0.90024	0.80216
	24	0.851694915	0.8512	0.900344	0.802056
	27	0.805615551	0.8512	0.900819	0.801581
	28	0.848101266	0.8512	0.90024	0.80216
	29	0.848101266	0.8512	0.90024	0.80216
	30	0.849462366	0.8512	0.900712	0.801688
august	3	0.941947566	0.8512	0.897403	0.804997
	4	0.779026217	0.8512	0.897403	0.804997
	5	0.887640449	0.8512	0.897403	0.804997
	6	0.833333333	0.8512	0.897403	0.804997
	7	0.938818565	0.8512	0.90024	0.80216
	10	0.832589286	0.8512	0.901643	0.800757
	13	0.970464135	0.8512	0.90024	0.80216
	15	0.757383966	0.8512	0.90024	0.80216
	17	0.937931034	0.8512	0.902391	0.800009
	18	0.67047619	0.8512	0.897797	0.804603
	19	0.737827715	0.8512	0.897403	0.804997
	20	0.890295359	0.8512	0.90024	0.80216
	21	0.923220974	0.8512	0.897403	0.804997
	22	0.981012658	0.8512	0.90024	0.80216
	24	0.936708861	0.8512	0.90024	0.80216
	25	0.981693364	0.8512	0.902274	0.800126
	26	0.966244726	0.8512	0.90024	0.80216
	27	0.742616034	0.8512	0.90024	0.80216
sept	3	0.864244742	0.8512	0.897886	0.804514
	4	0.69844358	0.8512	0.898293	0.804107
	10	0.847639485	0.8512	0.900659	0.801741
	11	0.738255034	0.8512	0.901699	0.800701
	12	0.924050633	0.8512	0.90024	0.80216
	14	0.853862213	0.8512	0.899983	0.802417
	17	0.851380042	0.8512	0.900396	0.802004
	18	0.923220974	0.8512	0.897403	0.804997
	19	0.950570342	0.8512	0.897753	0.804647
	21	0.903157895	0.8512	0.900188	0.802212
	22	0.845991561	0.8512	0.90024	0.80216
	28	0.885106383	0.8512	0.900448	0.801952
	29	0.936956522	0.8512	0.900981	0.801419
	30	0.622881356	0.8512	0.900344	0.802056

shift B					
	DAY	PERFORMANCE (P)	CENTER P BAR	UCL	LCL
july	1	0.848101266	0.824	0.876475	0.771525
	2	0.803797468	0.824	0.876475	0.771525
	3	0.862869198	0.824	0.876475	0.771525
	6	0.924050633	0.824	0.876475	0.771525
	7	0.9092827	0.824	0.876475	0.771525
	8	0.9092827	0.824	0.876475	0.771525
	9	0.833333333	0.824	0.876475	0.771525
	10	0.772151899	0.824	0.876475	0.771525
	11	0.757383966	0.824	0.876475	0.771525
	13	0.848101266	0.824	0.876475	0.771525
	14	0.786919831	0.824	0.876475	0.771525
	22	0.848101266	0.824	0.876475	0.771525
	23	0.757383966	0.824	0.876475	0.771525
	24	0.772151899	0.824	0.876475	0.771525
	27	0.848101266	0.824	0.876475	0.771525
	28	0.757383966	0.824	0.876475	0.771525
	29	0.757383966	0.824	0.876475	0.771525
	30	0.861052632	0.824	0.87642	0.77158
august	3	0.941947566	0.824	0.873439	0.774561
	4	0.848101266	0.824	0.876475	0.771525
	5	0.807116105	0.824	0.873439	0.774561
	6	0.833333333	0.824	0.873439	0.774561
	7	0.895705521	0.824	0.875664	0.772336
	10	0.713483146	0.824	0.873439	0.774561
	11	0.798611111	0.824	0.871603	0.776397
	13	1	0.824	0.876475	0.771525
	14	0.900749064	0.824	0.873439	0.774561
	15	0.757383966	0.824	0.876475	0.771525
	17	0.565400844	0.824	0.876475	0.771525
	18	0.632958801	0.824	0.873439	0.774561
	18	0.632958801	0.824	0.873439	0.774561
	20	0.890295359	0.824	0.876475	0.771525
	21	0.8200409	0.824	0.875664	0.772336
	22	0.801687764	0.824	0.876475	0.771525
	24	0.995780591	0.824	0.876475	0.771525
	25	0.995780591	0.824	0.876475	0.771525
	26	1.040084388	0.824	0.876475	0.771525
	27	0.786919831	0.824	0.876475	0.771525
sept	1	0.727848101	0.824	0.876475	0.771525
	2	0.786919831	0.824	0.876475	0.771525
	3	0.765917603	0.824	0.873439	0.774561
	4	0.9092827	0.824	0.876475	0.771525
	7	1.042944785	0.824	0.875664	0.772336
	8	0.803669725	0.824	0.872938	0.775062
	9	0.68440367	0.824	0.872938	0.775062
	10	0.752808989	0.824	0.873439	0.774561
	11	0.748263889	0.824	0.871603	0.776397
	12	0.938818565	0.824	0.876475	0.771525
	14	0.900749064	0.824	0.873439	0.774561
	15	0.666666667	0.824	0.876475	0.771525
	17	0.836518047	0.824	0.876475	0.771525
	18	0.580524345	0.824	0.876475	0.771525
	19	0.923220974	0.824	0.876475	0.771525
	21	0.862985685	0.824	0.876475	0.771525
	22	0.845991561	0.824	0.876475	0.771525
	28	0.871681416	0.824	0.876475	0.771525
	29	0.742616034	0.824	0.876475	0.771525
	30	0.905063291	0.824	0.876475	0.771525

C3: Control Chart Data for Quality by Shifts

shift A					
	DAY	QUALITY (p)	CENTER (P-BAR)	UCL	LCL
july	1	0.963636364	0.9539	1.038729	0.869071
	2	0.981818182	0.9539	1.038729	0.869071
	3	1	0.9539	1.042869	0.864931
	6	0.966666667	0.9539	1.035117	0.872683
	7	0.98245614	0.9539	1.037227	0.870573
	8	0.904761905	0.9539	1.03316	0.87464
	9	0.94	0.9539	1.042869	0.864931
	10	0.96	0.9539	1.042869	0.864931
	11	0.961538462	0.9539	1.041141	0.866659
	13	1	0.9539	1.040314	0.867486
	14	0.981818182	0.9539	1.038729	0.869071
	22	0.964912281	0.9539	1.037227	0.870573
	23	0.964285714	0.9539	1.037968	0.869832
	24	0.982142857	0.9539	1.037968	0.869832
	27	1	0.9539	1.041141	0.866659
	28	1	0.9539	1.037968	0.869832
	29	0.964285714	0.9539	1.037968	0.869832
	30	0.981818182	0.9539	1.038729	0.869071
august	3	0.971428571	0.9539	1.029092	0.878708
	4	0.982758621	0.9539	1.036506	0.871294
	5	0.96969697	0.9539	1.031337	0.876463
	6	0.983870968	0.9539	1.033796	0.874004
	7	0.935483871	0.9539	1.033796	0.874004
	10	0.942307692	0.9539	1.041141	0.866659
	13	0.9375	0.9539	1.032538	0.875262
	15	0.9	0.9539	1.042869	0.864931
	17	0.896551724	0.9539	1.036506	0.871294
	18	0.96	0.9539	1.042869	0.864931
	19	0.946428571	0.9539	1.037968	0.869832
	20	0.95	0.9539	1.035117	0.872683
	21	0.942857143	0.9539	1.029092	0.878708
	22	0.96969697	0.9539	1.031337	0.876463
	24	0.968253968	0.9539	1.03316	0.87464
	25	0.967213115	0.9539	1.034449	0.873351
	26	0.953846154	0.9539	1.031931	0.875869
	27	0.9	0.9539	1.042869	0.864931
sept	3	0.984126984	0.9539	1.03316	0.87464
	4	0.9	0.9539	1.042869	0.864931
	10	1	0.9539	1.038729	0.869071
	11	1	0.9539	1.046656	0.861144
	12	1	0.9539	1.034449	0.873351
	14	1	0.9539	1.037227	0.870573
	17	0.754385965	0.9539	1.037227	0.870573
	18	0.914285714	0.9539	1.029092	0.878708
	19	0.929577465	0.9539	1.028561	0.879239
	21	0.901639344	0.9539	1.034449	0.873351
	22	0.964912281	0.9539	1.037227	0.870573
	28	0.913793103	0.9539	1.036506	0.871294
	29	1	0.9539	1.035117	0.872683
	30	0.853658537	0.9539	1.05215	0.85565

shift B					
	DAY	QUALITY (P)	CENTER (P-BAR)	UCL	LCL
july	1	1	0.9749	1.037611	0.912189
	2	0.962264151	0.9749	1.039361	0.910439
	3	0.964912281	0.9749	1.037059	0.912741
	6	0.967213115	0.9749	1.034986	0.914814
	7	0.966666667	0.9749	1.035485	0.914315
	8	0.933333333	0.9749	1.035485	0.914315
	9	0.963636364	0.9749	1.038179	0.911621
	10	0.980392157	0.9749	1.040613	0.909187
	11	0.96	0.9749	1.041267	0.908533
	13	0.964285714	0.9749	1.037611	0.912189
	14	0.961538462	0.9749	1.039978	0.909822
	22	0.964285714	0.9749	1.037611	0.912189
	23	1	0.9749	1.041267	0.908533
	24	1	0.9749	1.040613	0.909187
	27	1	0.9749	1.037611	0.912189
	28	0.94	0.9749	1.041267	0.908533
	29	1	0.9749	1.041267	0.908533
	30	1	0.9749	1.041267	0.908533
august	3	0.971428571	0.9749	1.03099	0.91881
	4	0.982142857	0.9749	1.037611	0.912189
	5	0.966666667	0.9749	1.035485	0.914315
	6	0.983870968	0.9749	1.034499	0.915301
	7	0.950819672	0.9749	1.034986	0.914814
	10	0.962264151	0.9749	1.039361	0.910439
	11	0.96875	0.9749	1.033561	0.916239
	13	0.96969697	0.9749	1.032665	0.917135
	14	0.970149254	0.9749	1.032232	0.917568
	15	0.98	0.9749	1.041267	0.908533
	17	0.973684211	0.9749	1.051028	0.898772
	18	0.958333333	0.9749	1.042636	0.907164
	18	0.979166667	0.9749	1.042636	0.907164
	20	0.95	0.9749	1.035485	0.914315
	21	0.98245614	0.9749	1.037059	0.912741
	22	0.962962963	0.9749	1.038762	0.911038
	24	0.970149254	0.9749	1.032232	0.917568
	25	0.970149254	0.9749	1.032232	0.917568
	26	0.985714286	0.9749	1.03099	0.91881
	27	0.943396226	0.9749	1.039361	0.910439
sept	1	1	0.9749	1.042636	0.907164
	2	1	0.9749	1.039978	0.909822
	3	1	0.9749	1.037059	0.912741
	4	0.95	0.9749	1.035485	0.914315
	7	1	0.9749	1.030594	0.919206
	8	1	0.9749	1.034986	0.914814
	9	0.980769231	0.9749	1.039978	0.909822
	10	0.982142857	0.9749	1.037611	0.912189
	11	1	0.9749	1.035485	0.914315
	12	0.983870968	0.9749	1.034499	0.915301
	14	1	0.9749	1.032232	0.917568
	15	1	0.9749	1.045648	0.904152
	17	0.964285714	0.9749	1.001994	0.947806
	18	1	0.9749	1.001994	0.947806
	19	1	0.9749	1.001994	0.947806
	21	1	0.9749	1.001994	0.947806
	22	1	0.9749	1.001994	0.947806
	28	0.803571429	0.9749	1.001994	0.947806
	29	1	0.9749	1.001994	0.947806
	30	0.967213115	0.9749	1.001994	0.947806

C4: Control Chart Data for OEE by Shifts

shift A					
	DAY	OEE	CENTER (P-BAR)	UCL	LCL
july	1	0.8	0.8049	0.859505	0.750295
	2	0.82	0.8049	0.859505	0.750295
	3	0.76	0.8049	0.859505	0.750295
	6	0.88	0.8049	0.859505	0.750295
	7	0.85	0.8049	0.859505	0.750295
	8	0.86	0.8049	0.859505	0.750295
	9	0.71	0.8049	0.859505	0.750295
	10	0.73	0.8049	0.859505	0.750295
	11	0.76	0.8049	0.859505	0.750295
	13	0.8	0.8049	0.859505	0.750295
	14	0.82	0.8049	0.859505	0.750295
	22	0.83	0.8049	0.859505	0.750295
	23	0.82	0.8049	0.859505	0.750295
	24	0.83	0.8049	0.85962	0.75018
	27	0.79	0.8049	0.86015	0.74965
	28	0.85	0.8049	0.859505	0.750295
	29	0.82	0.8049	0.859505	0.750295
	30	0.82	0.8049	0.860031	0.749769
august	3	0.915	0.8049	0.856346	0.753454
	4	0.766	0.8049	0.856346	0.753454
	5	0.861	0.8049	0.856346	0.753454
	6	0.82	0.8049	0.856346	0.753454
	7	0.878	0.8049	0.859505	0.750295
	10	0.742	0.8049	0.861067	0.748733
	13	0.91	0.8049	0.859505	0.750295
	15	0.682	0.8049	0.859505	0.750295
	17	0.772	0.8049	0.8619	0.7479
	18	0.633	0.8049	0.856785	0.753015
	19	0.698	0.8049	0.856346	0.753454
	20	0.846	0.8049	0.859505	0.750295
	21	0.87	0.8049	0.856346	0.753454
	22	0.951	0.8049	0.859505	0.750295
	24	0.907	0.8049	0.859505	0.750295
	25	0.875	0.8049	0.86177	0.74803
	26	0.922	0.8049	0.859505	0.750295
	27	0.668	0.8049	0.859505	0.750295
sept	3	0.833	0.8049	0.856884	0.752916
	4	0.605	0.8049	0.857337	0.752463
	10	0.833	0.8049	0.859972	0.749828
	11	0.724	0.8049	0.86113	0.74867
	12	0.924	0.8049	0.859505	0.750295
	14	0.845	0.8049	0.859219	0.750581
	17	0.638	0.8049	0.859679	0.750121
	18	0.844	0.8049	0.856346	0.753454
	19	0.87	0.8049	0.856736	0.753064
	21	0.808	0.8049	0.859447	0.750353
	22	0.816	0.8049	0.859505	0.750295
	28	0.802	0.8049	0.859737	0.750063
	29	0.909	0.8049	0.86033	0.74947
	30	0.529	0.8049	0.85962	0.75018

shift B					
	DAY	OEE	CENTER (P-BAR)	UCL	LCL
july	1	0.85	0.8029	0.857716	0.748084
	2	0.77	0.8029	0.857716	0.748084
	3	0.83	0.8029	0.857716	0.748084
	6	0.89	0.8029	0.857716	0.748084
	7	0.88	0.8029	0.857716	0.748084
	8	0.85	0.8029	0.857716	0.748084
	9	0.8	0.8029	0.857716	0.748084
	10	0.76	0.8029	0.857716	0.748084
	11	0.73	0.8029	0.857716	0.748084
	13	0.82	0.8029	0.857716	0.748084
	14	0.76	0.8029	0.857716	0.748084
	22	0.82	0.8029	0.857716	0.748084
	23	0.76	0.8029	0.857716	0.748084
	24	0.77	0.8029	0.857716	0.748084
	27	0.85	0.8029	0.857716	0.748084
	28	0.71	0.8029	0.857716	0.748084
	29	0.76	0.8029	0.857716	0.748084
	30	0.86	0.8029	0.857716	0.748084
august	3	0.92	0.8029	0.857716	0.748084
	4	0.83	0.8029	0.857716	0.748084
	5	0.78	0.8029	0.857716	0.748084
	6	0.82	0.8029	0.857716	0.748084
	7	0.85	0.8029	0.857716	0.748084
	10	0.69	0.8029	0.857716	0.748084
	11	0.77	0.8029	0.857716	0.748084
	13	0.97	0.8029	0.857716	0.748084
	14	0.87	0.8029	0.857716	0.748084
	15	0.74	0.8029	0.857716	0.748084
	17	0.55	0.8029	0.857716	0.748084
	18	0.61	0.8029	0.857716	0.748084
	18	0.62	0.8029	0.857716	0.748084
	20	0.85	0.8029	0.857716	0.748084
	21	0.81	0.8029	0.857716	0.748084
	22	0.77	0.8029	0.857716	0.748084
	24	0.97	0.8029	0.857716	0.748084
	25	0.97	0.8029	0.857716	0.748084
	26	1.03	0.8029	0.857716	0.748084
	27	0.74	0.8029	0.857716	0.748084
sept	1	0.73	0.8029	0.857716	0.748084
	2	0.79	0.8029	0.857716	0.748084
	3	0.77	0.8029	0.857716	0.748084
	4	0.86	0.8029	0.857716	0.748084
	7	1.04	0.8029	0.857716	0.748084
	8	0.8	0.8029	0.857716	0.748084
	9	0.67	0.8029	0.857716	0.748084
	10	0.74	0.8029	0.857716	0.748084
	11	0.75	0.8029	0.857716	0.748084
	12	0.92	0.8029	0.857716	0.748084
	14	0.9	0.8029	0.857716	0.748084
	15	0.67	0.8029	0.857716	0.748084
	17	0.8	0.8029	0.857716	0.748084
	18	0.58	0.8029	0.857716	0.748084
	19	0.92	0.8029	0.857716	0.748084
	21	0.86	0.8029	0.857716	0.748084
	22	0.85	0.8029	0.857716	0.748084
	28	0.67	0.8029	0.857716	0.748084
	29	0.74	0.8029	0.857716	0.748084
	30	0.88	0.8029	0.857716	0.748084

APPENDIX D

D1: Attribute Control Chart, p-chart Formula

For finding average, Centreline:	$\bar{p} = \frac{\sum np}{\sum n}$
Upper Control Limit, UCL:	$UCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$
Lower Control Limit, LCL:	$LCL_p = \bar{p} - 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$

APPENDIX E

E1: Calculation for availability factor on July 1st 2015 for Shift A for existing condition

$\bar{p} = \frac{24136}{24357}$

$= 0.9909$

$UCL_p = 0.9909 + 3\sqrt{\frac{0.9909\ (1-0.9909)}{474}}$

$= 1.0040$

$LCL_p = 0.9909 - 3\sqrt{\frac{0.9909\ (1-0.9909)}{474}}$

$= 0.9778$

E2: Calculation for availability factor on July 1st 2015 for Shift A for 1st revised condition

$\bar{p} = \frac{21379}{21453}$

$= 0.9966$

$UCL_p = 0.9966 + 3\sqrt{\frac{0.9966\ (1-0.9966)}{474}}$

$= 1.0046$

$LCL_p = 0.9966 - 3\sqrt{\frac{0.9966(1-0.9966)}{474}}$

$= 0.9886$

APPENDIX F

F1: Revised Control Chart Data for Availability by Shifts

shift A

	DAY	OPERATION TIME	PLANNED PRODUCTION TIME	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL
july	1-Jul-15	474	474	1.00	0.9966	1.0046	0.9886
	2	474	474	1.00	0.9966	1.0046	0.9886
	3	474	474	1.00	0.9966	1.0046	0.9886
	6	474	474	1.00	0.9966	1.0046	0.9886
	7	474	474	1.00	0.9966	1.0046	0.9886
	8	474	474	1.00	0.9966	1.0046	0.9886
	9	474	474	1.00	0.9966	1.0046	0.9886
	10	474	474	1.00	0.9966	1.0046	0.9886
	11	474	474	1.00	0.9966	1.0046	0.9886
	13	474	474	1.00	0.9966	1.0046	0.9886
	14	474	474	1.00	0.9966	1.0046	0.9886
	22	474	474	1.00	0.9966	1.0046	0.9886
	23	474	474	1.00	0.9966	1.0046	0.9886
	24	472	474	1.00	0.9966	1.0046	0.9886
	28	474	474	1.00	0.9966	1.0046	0.9886
	29	474	474	1.00	0.9966	1.0046	0.9886
	30	465	474	0.98	0.9966	1.0046	0.9886
august	3-Aug-15	534	534	1.00	0.9966	1.0042	0.9890
	4	534	534	1.00	0.9966	1.0042	0.9890
	5	534	534	1.00	0.9966	1.0042	0.9890
	6	534	534	1.00	0.9966	1.0042	0.9890
	7	474	474	1.00	0.9966	1.0046	0.9886
	13	474	474	1.00	0.9966	1.0046	0.9886
	15	474	474	1.00	0.9966	1.0046	0.9886
	18	525	534	0.98	0.9966	1.0042	0.9890
	19	534	534	1.00	0.9966	1.0042	0.9890
	20	474	474	1.00	0.9966	1.0046	0.9886
	21	534	534	1.00	0.9966	1.0042	0.9890
	22	474	474	1.00	0.9966	1.0046	0.9886
	24	474	474	1.00	0.9966	1.0046	0.9886
	26	474	474	1.00	0.9966	1.0046	0.9886
	27	474	474	1.00	0.9966	1.0046	0.9886
sept	3-Sep-15	523	534	0.98	0.9966	1.0042	0.9890
	10	466	474	0.98	0.9966	1.0046	0.9886
	11	447	456	0.98	0.9966	1.0048	0.9884
	12	474	474	1.00	0.9966	1.0046	0.9886
	14	479	484	0.99	0.9966	1.0045	0.9887
	17	471	474	0.99	0.9966	1.0046	0.9886
	18	534	534	1.00	0.9966	1.0042	0.9890
	19	526	534	0.99	0.9966	1.0042	0.9890
	21	475	479	0.99	0.9966	1.0046	0.9886
	22	474	474	1.00	0.9966	1.0046	0.9886
	28-Sep	470	474	0.99	0.9966	1.0046	0.9886
	30	472	474	1.00	0.9966	1.0046	0.9886

shift B

	DAY	OPERATION TIME	PLANNED PRODUCTION TIME	AVAILABILITY (p)	CENTER (P-BAR)	UCL	LCL
july	1-Jul-15	474	474	1.00	0.999	1.00	1.00
	2	474	474	1.00	0.999	1.00	1.00
	3	474	474	1.00	0.999	1.00	1.00
	6	474	474	1.00	0.999	1.00	1.00
	7	474	474	1.00	0.999	1.00	1.00
	8	474	474	1.00	0.999	1.00	1.00
	9	474	474	1.00	0.999	1.00	1.00
	10	474	474	1.00	0.999	1.00	1.00
	11	474	474	1.00	0.999	1.00	1.00
	13	474	474	1.00	0.999	1.00	1.00
	14	474	474	1.00	0.999	1.00	1.00
	22	474	474	1.00	0.999	1.00	1.00
	23	474	474	1.00	0.999	1.00	1.00
	24	474	474	1.00	0.999	1.00	1.00
	27	474	474	1.00	0.999	1.00	1.00
	28	474	474	1.00	0.999	1.00	1.00
	29	474	474	1.00	0.999	1.00	1.00
	30	475	475	1.00	0.999	1.00	1.00
august	3-Aug-15	534	534	1.00	0.999	1.00	1.00
	4	474	474	1.00	0.999	1.00	1.00
	5	534	534	1.00	0.999	1.00	1.00
	6	534	534	1.00	0.999	1.00	1.00
	7	489	489	1.00	0.999	1.00	1.00
	10	534	534	1.00	0.999	1.00	1.00
	11	576	576	1.00	0.999	1.00	1.00
	13	474	474	1.00	0.999	1.00	1.00
	14	534	534	1.00	0.999	1.00	1.00
	15	474	474	1.00	0.999	1.00	1.00
	17	474	474	1.00	0.999	1.00	1.00
	18	534	534	1.00	0.999	1.00	1.00
	18	534	534	1.00	0.999	1.00	1.00
	20	474	474	1.00	0.999	1.00	1.00
	21	489	489	1.00	0.999	1.00	1.00
	22	474	474	1.00	0.999	1.00	1.00
	24	474	474	1.00	0.999	1.00	1.00
	25-Aug-15	474	474	1.00	0.999	1.00	1.00
	26	474	474	1.00	0.999	1.00	1.00
	27	474	474	1.00	0.999	1.00	1.00
sept	1-Sep-15	474	474	1.00	0.999	1.00	1.00
	2	474	474	1.00	0.999	1.00	1.00
	3	534	534	1.00	0.999	1.00	1.00
	4	474	474	1.00	0.999	1.00	1.00
	7	489	489	1.00	0.999	1.00	1.00
	8	545	545	1.00	0.999	1.00	1.00
	9	545	545	1.00	0.999	1.00	1.00
	10	534	534	1.00	0.999	1.00	1.00
	11-Sep	576	576	1.00	0.999	1.00	1.00
	12	474	474	1.00	0.999	1.00	1.00
	14	534	534	1.00	0.999	1.00	1.00
	15	474	474	1.00	0.999	1.00	1.00
	18	534	534	1.00	0.999	1.00	1.00
	19	534	534	1.00	0.999	1.00	1.00
	21	489	489	1.00	0.999	1.00	1.00
	22	474	474	1.00	0.999	1.00	1.00
	29	474	474	1.00	0.999	1.00	1.00
	30	474	474	1.00	0.999	1.00	1.00

F2: Revised Control Chart Data for Performance by Shifts

shift A								shift B							
	DAY	NET OPERATION TIME (np)	OPERATION TIME (n)	PERFORMANCE (p)	CENTER P BAR	UCL	LCL		DAY	NET OPERATION TIME	PERATION TIM	PERFORMANCE (P)	CENTER P BAR	UCL	LCL
	1-Jul-15	395	474	0.833	0.8490	0.8983	0.7997		1-Jul-15	402	474	0.848	0.8287	0.8287	0.8287
	2	395	474	0.833	0.8490	0.8983	0.7997		2	381	474	0.804	0.8287	0.8287	0.8287
	7	409	474	0.863	0.8490	0.8983	0.7997		3	409	474	0.863	0.8287	0.8287	0.8287
	13	381	474	0.804	0.8490	0.8983	0.7997		9	395	474	0.833	0.8287	0.8287	0.8287
	14	395	474	0.833	0.8490	0.8983	0.7997	july	13	402	474	0.848	0.8287	0.8287	0.8287
july	22	409	474	0.863	0.8490	0.8983	0.7997		14	373	474	0.787	0.8287	0.8287	0.8287
	23	402	474	0.848	0.8490	0.8983	0.7997		22	402	474	0.848	0.8287	0.8287	0.8287
	24	402	472	0.852	0.8490	0.8984	0.7996		27	402	474	0.848	0.8287	0.8287	0.8287
	27	373	463	0.806	0.8490	0.8989	0.7991		30	409	475	0.861	0.8287	0.8287	0.8287
	28	402	474	0.848	0.8490	0.8983	0.7997		4	402	474	0.848	0.8287	0.8287	0.8287
	29	402	474	0.848	0.8490	0.8983	0.7997		5	431	534	0.807	0.8287	0.8287	0.8287
	30	395	465	0.849	0.8490	0.8988	0.7992		6	445	534	0.833	0.8287	0.8287	0.8287
	5	474	534	0.888	0.8490	0.8955	0.8025	august	11	460	576	0.799	0.8287	0.8287	0.8287
august	6	445	534	0.833	0.8490	0.8955	0.8025		21	401	489	0.820	0.8287	0.8287	0.8287
	10	373	448	0.833	0.8490	0.8997	0.7983		22	380	474	0.802	0.8287	0.8287	0.8287
	20	422	474	0.890	0.8490	0.8983	0.7997		27	373	474	0.787	0.8287	0.8287	0.8287
	3-Sep-15	452	523	0.864	0.8490	0.8960	0.8020		2	373	474	0.787	0.8287	0.8287	0.8287
	10	395	466	0.848	0.8490	0.8988	0.7992		8	438	545	0.804	0.8287	0.8287	0.8287
sept	14	409	479	0.854	0.8490	0.8981	0.7999	sept	17	394	471	0.837	0.8287	0.8287	0.8287
	17	401	471	0.851	0.8490	0.8985	0.7995		21	422	489	0.863	0.8287	0.8287	0.8287
	22	401	474	0.846	0.8490	0.8983	0.7997		22	401	474	0.846	0.8287	0.8287	0.8287
	28-Sep	416	470	0.885	0.8490	0.8985	0.7995		28	394	452	0.872	0.8287	0.8287	0.8287

F3: Revised Control Chart Data for Quality by Shifts

shift A

	DAY	OK PRODUCT PER SHIFT (np)	TOTAL OUTPUT PER SHIFT (n)	QUALITY (p)	CENTER (P-BAR)	UCL	LCL
july	1-Jul-15	53	55	0.964	0.9597	1.0393	0.8801
	2	54	55	0.982	0.9597	1.0393	0.8801
	3	50	50	1.000	0.9597	1.0431	0.8763
	6	58	60	0.967	0.9597	1.0359	0.8835
	7	56	57	0.982	0.9597	1.0378	0.8816
	8	57	63	0.905	0.9597	1.0340	0.8854
	9	47	50	0.940	0.9597	1.0431	0.8763
	10	48	50	0.960	0.9597	1.0431	0.8763
	11	50	52	0.962	0.9597	1.0415	0.8779
	13	53	53	1.000	0.9597	1.0407	0.8787
	14	54	55	0.982	0.9597	1.0393	0.8801
	22	55	57	0.965	0.9597	1.0378	0.8816
	23	54	56	0.964	0.9597	1.0385	0.8809
	24	55	56	0.982	0.9597	1.0385	0.8809
	27	52	52	1.000	0.9597	1.0415	0.8779
	28	56	56	1.000	0.9597	1.0385	0.8809
	29-Jul-15	54	56	0.964	0.9597	1.0385	0.8809
	30	54	55	0.982	0.9597	1.0393	0.8801
august	3-Aug-15	68	70	0.971	0.9597	1.0302	0.8892
	4	57	58	0.983	0.9597	1.0372	0.8822
	5	64	66	0.970	0.9597	1.0323	0.8871
	6-Aug	61	62	0.984	0.9597	1.0346	0.8848
	7	58	62	0.94	0.9597	1.0346	0.8848
	10	49	52	0.94	0.9597	1.0415	0.8779
	13	60	64	0.94	0.9597	1.0334	0.8860
	15	45	50	0.90	0.9597	1.0431	0.8763
	17	52	58	0.90	0.9597	1.0372	0.8822
	18	48	50	0.96	0.9597	1.0431	0.8763
	19	53	56	0.95	0.9597	1.0385	0.8809
	20	57	60	0.95	0.9597	1.0359	0.8835
	21	66	70	0.94	0.9597	1.0302	0.8892
	22	64	66	0.97	0.9597	1.0323	0.8871
	24-Aug-15	61	63	0.97	0.9597	1.0340	0.8854
	25	59	61	0.97	0.9597	1.0352	0.8842
	26	62	65	0.95	0.9597	1.0329	0.8865
	27	45	50	0.90	0.9597	1.0431	0.8763
sept	3-Sep-15	62	63	0.98	0.9597	1.0340	0.8854
	4	45	50	0.90	0.9597	1.0431	0.8763
	10	55	55	1.00	0.9597	1.0393	0.8801
	11	46	46	1.00	0.9597	1.0467	0.8727
	12	61	61	1.00	0.9597	1.0352	0.8842
	14	57	57	1.00	0.9597	1.0378	0.8816
	18-Sep	64	70	0.91	0.9597	1.0302	0.8892
	19	66	71	0.93	0.9597	1.0297	0.8897
	21	55	61	0.90	0.96	1.04	0.88
	22	55	57	0.96	0.96	1.04	0.88
	28-Sep-15	53	58	0.91	0.96	1.04	0.88
	29	60	60	1.00	0.96	1.04	0.88

shift B

	DAY	OK PRODUCT PER SHIFT	TOTAL OUTPUT PER SHIFT	QUALITY (P)	CENTER (P-BAR)	UCL	LCL
july	1-Jul-15	56	56	1.000	0.9777	1.0369	0.9185
	2	51	53	0.962	0.9777	1.0385	0.9169
	3	55	57	0.965	0.9777	1.0364	0.9190
	6	59	61	0.967	0.9777	1.0344	0.9210
	7	58	60	0.967	0.9777	1.0349	0.9205
	8	56	60	0.933	0.9777	1.0349	0.9205
	9	53	55	0.964	0.9777	1.0374	0.9180
	10	50	51	0.980	0.9777	1.0397	0.9157
	11	48	50	0.960	0.9777	1.0403	0.9151
	13	54	56	0.964	0.9777	1.0369	0.9185
	14	50	52	0.962	0.9777	1.0391	0.9163
	22	54	56	0.964	0.9777	1.0369	0.9185
	23	50	50	1.000	0.9777	1.0403	0.9151
	24	51	51	1.000	0.9777	1.0397	0.9157
	27	56	56	1.000	0.9777	1.0369	0.9185
	28	47	50	0.940	0.9777	1.0403	0.9151
	29	50	50	1.000	0.9777	1.0403	0.9151
	30	50	50	1.000	0.9777	1.0403	0.9151
august	3-Aug-15	68	70	0.971	0.9777	1.0306	0.9248
	4	55	56	0.982	0.9777	1.0369	0.9185
	5	58	60	0.967	0.9777	1.0349	0.9205
	6	61	62	0.984	0.9777	1.0340	0.9214
	7	58	61	0.95	0.978	1.03	0.92
	10	51	53	0.96	0.978	1.04	0.92
	11	62	64	0.97	0.978	1.03	0.92
	13	64	66	0.97	0.978	1.03	0.92
	14	65	67	0.97	0.978	1.03	0.92
	15	49	50	0.98	0.978	1.04	0.92
	17	37	38	0.97	0.978	1.05	0.91
	18	46	48	0.96	0.978	1.04	0.91
	18	47	48	0.98	0.978	1.04	0.91
	20	57	60	0.95	0.978	1.03	0.92
	21	56	57	0.98	0.978	1.04	0.92
	22	52	54	0.96	0.978	1.04	0.92
	24	65	67	0.97	0.978	1.03	0.92
	25-Aug-15	65	67	0.97	0.978	1.03	0.92
	26	69	70	0.99	0.978	1.03	0.92
	27	50	53	0.94	0.978	1.04	0.92
sept	1-Sep-15	48	48	1.00	0.978	1.04	0.91
	2	52	52	1.00	0.978	1.04	0.92
	3	57	57	1.00	0.978	1.04	0.92
	4	57	60	0.95	0.978	1.03	0.92
	7	71	71	1.00	0.978	1.03	0.93
	8	61	61	1.00	0.978	1.03	0.92
	9	51	52	0.98	0.978	1.04	0.92
	10	55	56	0.98	0.978	1.04	0.92
	11-Sep	60	60	1.00	0.978	1.03	0.92
	12	61	62	0.98	0.978	1.03	0.92
	14	67	67	1.00	0.978	1.03	0.92
	15	44	44	1.00	0.978	1.04	0.91
	17	54	56	0.96	0.978	1.00	0.95
	18	44	44	1.00	0.978	1.00	0.95
	19	70	70	1.00	0.978	1.00	0.95
	21	60	60	1.00	0.978	1.00	0.95
	22	57	57	1.00	0.978	1.00	0.95
	29	50	50	1.00	0.978	1.00	0.95
	30	59	61	0.967	0.978	1.003	0.952