DESIGN AND IMPLEMENTATION OF ELECTRONIC GEMBA BOARDS

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DESIGN AND IMPLEMENTATION OF ELECTRONIC GEMBA BOARDS

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Abstract: Lean manufacturing (LM) is a philosophy that focuses on decreasing the waste generated in a product or process and continuously adding value for the end consumer. There are many different tools that are used to accomplish this object, with a commonly used tool being Gemba. The purpose of Gemba is for the upper management of the company to go to the shop floor and examine the process that is taking place. To accomplish this objective, a visual tool known as the Gemba board is used to direct the conversations that occur on these walks and to display pertinent information for each department. The primary purpose of this research was the creation, implementation and impact of interactive Gemba boards on major aspects of business. The goal was to create interactive electronic information centers to replace the current method of data collection and analysis. At these stations' operators would be able to enter and access real-time data, as well as provide feedback on current problems and their completion level. Statistical

Process Control Tools, specifically Control Charts, Histograms and Pareto charts, were used to determine the impact that this new display method had on production, speed, cost, quality and the process as a whole. From the data it was determined that the aspects of the business that had seen the greatest changes since the initial implementation were the quality, cost, and process. The cost data remained constant, the number of nonconforming products decreased, and the process was statistically in greater control post implementation.

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Chapter 1: Introduction

1.1 Background of Lean Manufacturing

Lean manufacturing is a practice that can be traced back to the late 19th to the early 20th century (Ndahi, 2006). The organization that is given the credit for perfecting this system, as well as having the greatest success with this method, is Toyota. The Toyota Production System (TPS) is synonymous with modern day lean manufacturing and credited with being the starting point for the lean movement. The overall purpose of lean is to eliminate waste, which is defined as the use of any resources that do not directly relate or result in adding value to the product (Bhamu & Sangwan, 2014). As a whole, the method is designed to provide the best product possible for customers at the lowest price conceivable in a timely manner. A major advantage of this method is that it provides companies with a competitive edge, which is accomplished by improving overall productivity and quality, as well as reducing the cost of the product and production.

1.2 Background of Quality Control

Quality has several common definitions, such as the fitness of a product for its intended use or function, and the more modern definition that it is inversely proportional to the variability of a process (Douglas C. Montgomery, 2013e). Quality control refers to the systems that are created to ensure that the products and standards that are set by the company and upper management are maintained. The systems that are created consist of various statistical control methods, which include statistical control charts, design of experiments, and acceptance sampling. The uses of statistical quality control have an extensive history that can be traced back to the 1920's, with its adoption into manufacturing and industry dating back to the 1940's (Douglas C. Montgomery, 2013e). In the 1980's a large increase in the number of facilities and

businesses that adopted this method of analysis occurred. The occurrence of this event is attributed to the start of the lean manufacturing movement, which occurred at approximately the same time. Lean manufacturing techniques both heavily rely on and incorporate quality control tools and methods.

1.3 Background of Gemba

To accomplish the overall objective of lean manufacturing there are many different tools that are used. One of the main tools is *Gemba*, which is a Japanese term meaning to go and see (Imai, 1997). The purpose of *Gemba* is to have the upper level management within a company go to the shop floor to gain a better understanding of many different aspects of the business. Some of the specific areas of concentration include how processes are executed, understand why tasks take the time that they do, as well as which employees or departments accomplish certain tasks. Overall, the purpose of this tool is to have individuals go to where the processes within an organization are taking place and observing all aspects of the process.

1.4 Purpose of Research

The primary purpose of this research is the creation of interactive *Gemba* boards and to assess the impact of their implementation on major aspects of business. The goal of this research is to create interactive electronic information centers to replace the current method of data collection and analysis. At these stations, operators can enter and access real-time data, as well as provide data and feedback on current problems and their completion level. Control charts are used to determine the impact that this new display method has on the scrap totals, production, cost, and speed.

1.5 Objectives of the Research

The following points are the main objectives of this research.

- Design and creation of interactive Gemba boards based upon company criteria and suggestions.

- Implementation of the new Gemba boards into one of the departments and the shop floor.

- Analysis of data obtained by the interactive display using statistical process control charts and other quality control tools and techniques.

1.6 Significance of Research

The facility where this project took place has a strong *Gemba* program where walks were conducted at specific times throughout the week that encompassed all shifts and departments. To help direct the information that was discussed on these walks, as well as to engage the shop floor workers, *Gemba* Boards were created. The purpose of these boards is to have the workers involved in the collection of data and to direct the discussions that occur on the walks. These boards represented meeting locations for the walks and are sites where important information is displayed and updated. The design and content of these boards follow a specific set of standards that conforms to company guidelines. The original boards that were used were double-sided custom printed dry erase boards.

The creation of these new interactive *Gemba* boards will help areas meet the goals that were set with the original boards at a faster pace. The information that is presented will be more accurate and easier to maintain. The data that is collected is not only displayed, but is also stored in a centralized location on the network and can be accessed using any networked computer providing all individuals with up to date information. In addition, the data is stored in a specific

format that can be easily analyzed using various statistical analysis software and tools. In addition, there is no limit to the amount of information that can be accessed, which is to be compared to the original boards, which only displayed the data for the current month and was erased at the start of the next one. This method will provide extensive historical data, which can be used to find trends, document recurring problems, as well as many other factors.

1.7 Assumptions and Limitations

A limitation of this research is that there is a lack of historical data obtained using these boards at this facility. The original Gemba boards that have been used at this facility were integrated into the production process approximately three years ago. The data that was collected on the boards was documented by taking a picture. This method of documentation makes it hard to process and analyze the data based on the format and quality of the picture.

1.8 Definition of Terms

Gemba is a Japanese phrase meaning, "go and see" or "the real place".

Gemba Walk is where the upper management of a facility and/or company go down to the shop to gain a better understanding of the process and how and why each employee perform each task.

Gemba Board is a method used to have workers collect and record information daily about different aspects of the process. Some of the common information collected is the number of nonconforming products, number of products ran, the speed of the process and the cost of production.

Kaizen is the Japanese term for "continuous improvement" and focuses on making small improvements. Another major aspect of this technique is setting goals, constantly trying to achieve them, and raising them once they have been met (Comulada & Mendola, 2015).

Lean Manufacturing is a technique/philosophy that focuses on putting the needs of the customer first by decreasing costs and producing products at a speed that meets the demand of the customer (Bhamu & Sangwan, 2014).

Statistical Process Control (SPC) is a collection of problem solving tools that are used to analyze a process to help improve the capabilities and stability of the process by reducing process variability (Douglas C. Montgomery, 2013c).

Control Charts is a process monitoring technique used to monitor the performance of a process over time and to monitor and reduce variability.

Information Technology is the use of technology to obtain, store and retrieve data.

Quality is defined as being the ability of a product or process to meet its intended function and use and is inversely proportional to the variability of the process.

Quality Control is the system that is created to make sure that the standards and expectations that are set by the company and customer are met.

VBA stands for Visual Basic Applications which is a programming language specifically used and designed to work with Microsoft Applications, such as Excel and PowerPoint.

Macros are specific procedures or operations that are performed in a Microsoft application; they are created using the VBA language.

Chapter 2: Literature Review

2.1 Gemba

Lean manufacturing (LM) is a philosophy that focuses on decreasing the waste generated in a product or process and continuously adding value for the end consumer. Many tools accompany the LM philosophy and help to accomplish the objectives mentioned above. One of the most commonly used tools is Gemba, which is Japanese for "go and see". The focus of Gemba is going to the actual place where the work or process is occurring and examining all of the different components of the process (S.a, A.b, A.c, & d, 2013). The practice of going to a facility can apply to any individuals in a leadership position in an organization, which include the board or executive members of the company, process or design engineers, safety professionals, as well as many other individuals (Gesinger, 2016). The objective is to understand how and why employees perform their tasks the way that they do (Gesinger, 2016). This method targets both the quality, cost and delivery aspects of an organization, product, and process (Imai, 1997). By seeing the real environment, process, and the people in that environment, a better understanding of the issues affecting quality can be gained, as well as how those factors will affect the overall result. Implementing this technique also helps to modify the traditional hierarchy of a business, and encourages all members to contribute and offer suggestions on operational and organizational matters (Ballmer, n.d.). There are two key tools that are used to accomplish the objectives of *Gemba*; they are visual boards and the *Gemba* walk.

The first tool is a visual board, often referred to as a *Gemba* board that is used to direct conversation and display information. These boards are located at centralized locations within each department where the members of the team or department can gather. The gatherings usually take place once or twice per shift, typically at the beginning and end. At these meetings,

the content on the boards is updated, and in addition, these meetings serve as a time to share ideas and propose solutions to problems. The boards usually are standardized throughout the entire organization, but each area has the ability to customize some of the information to fit the needs of the department (Upvall, 2018). Two common methods are used to create these boards, the first being a bulletin board, on which the information is printed out and pinned to specific locations under specific titles or headers. The other method is a dry erase marker board, which are typically customized, sometimes even printed, to fit the type of information that is displayed. Overall, the purpose of these boards is to direct the flow of information and the conversation that takes place on the *Gemba* walks and shift meetings.

The *Gemba* walk is a designated time where the upper management of an organization go to the area where a process is taking place, including going to each of the different departments. There are four different common objectives for these excursions, which include setting challenging targets, seeing improvement opportunities, helping teams stay on tasks, and developing a support system throughout the organization (Forest, 2015). In the best use, conducting these walks will foster a shared vision and develop critical thinking skills throughout all levels of the organization. In order for these objectives to be accomplished, there are a couple of guidelines for these walks. The first is that a blame-free culture needs to be established, so that when questions are asked individuals will provide truthful answers (Insights, 2019). Also, the questions that are asked should be posed to find the needed information, not to trick, confuse or prove someone wrong. The questions should be thought provoking and help develop a deeper understanding of the process. These walks often occur at previously set or chosen times, one of which often matches the team huddles that are already occurring. Before these meetings, the upper management will typically view the board to get a sense of the current situation and then

watch the team members interact and discuss the information that is shown. By observing the interaction between the team members a greater understanding of their group dynamic, and the techniques utilized will be gained (Insights, 2019). The upper management will often participate or facilitate a discussion while interacting with these huddles.

2.2 Information Technology

Information Technology (IT) has pervaded much of modern-day life and affects all aspects of society. The first computers were introduced in the mid 1950's, and the early machine weighed approximately 5,000 pounds and took approximately three fourths of a second to complete a basic math problem (Resnikoff, 1984). What originally started out as military projects and tools in the 1940's, grew to the point where mainframes and similar devices were becoming widespread by the 1970's. Since the initial implementation, technology has made continuous strides forward at increasingly rapid rates. The importance of technology in the modern world can also be seen in the way money is invested, so that currently approximately 9% of the global economy is devoted to IT (Cortada, 2015). The key purpose of these devices when they were first created, and which remains at technology's foundation today, is to solve problems of varying levels of difficulty and complexity in order to provide valuable information.

Two key areas where IT is currently utilized are the manufacturing industry and the service industry. Throughout these industries, IT goes by many different names and is referred to in many different ways. The service industry, which includes schools, hospitals, banks and governments, refer to the computer systems that they utilize as IT. The manufacturing industry, however, has given other names to information technology, such as Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Manufacturing Resource Planning (MRP), computer integrated manufacturing, flexible manufacturing, as well as many others (Irani,

Ezingeard, & Grieve, 2005). The information technology used in this field ranges from the use of design software, to Programmable Logic Controllers, to robotics, all the way to data analysis. The information technology that is used today is often broken down into production technology, most commonly linked to manufacturing, and knowledge-based technology, which is commonly used in the service industry (Cuplan, 1995). There are three common reasons that IT is utilized: (1) to make decisions, (2) to provide control over processes and information, and (3) to increase the speed of operations. Additionally the implementation of IT in manufacturing has led to higher quality products, more flexibility in operations, lower production costs, as well as increased dependability and speed (Technologies & Cim, 2002).

The benefits of the implementation of IT in manufacturing can seem clear; however, a large portion of the workforce is still apprehensive about the integration of technology. A common topic of research over the past couple of decades has been the attitudes of individuals in work environments towards IT. Many of the different studies of this topic have concluded that the work environment that individuals are in is a very common motivator for individuals to increase their technical skills. Overall, the environment that management creates has a significant impact on the ability and willingness of employees to accept the integration of new technology (Cuplan, 1995)

2.3 Statistical Process Control (SPC) and Control Charts

Statistical Process Control (SPC) is a method that is used to monitor and control a process so that it can operate at its full potential and create the maximum number of conforming parts possible. SPC is used to detect and correct problems that occur during a process, while also providing early detection and prevention to limit the amount of variation in a process (Madanhire & Mbohwa, 2016). Seven common statistical tools make up the SPC collection, and these tools

are often referred to as the magnificent seven. The tools are histograms, check sheets, pareto charts, cause-and-effect diagrams, defect concentration diagram, scatter diagrams, and control charts (Douglas C. Montgomery, 2013d). Shewhart, Deming and Juran, who are some of the most well-known founders of these methods of analysis, created these tools. The creation of these methods can be traced back to the 1920's, when Shewhart started developing control charts to reduce variability.

The creation of these tools can be traced back to the early 1900's, with some dating back farther than that. However, their implementation in manufacturing broadened in the 1980's (Buch & Dave, 1993). These tools have been implemented in an extremely wide range of manufacturing operations, some examples including the automotive industry, chemical production, and consumer electronics. Other industries that have adopted these tools include health care, transportation, and the fast food industry (Rungtusanatham, 2001). To implement these processes successfully in an operation there are several common steps that need to be introduced into the process. First, the process needs to be defined and the measurables for the process need to be chosen. Once measurables have been chosen, they need to be examined to determine the natural variation that will occur in the process and how the variation will be tracked. After the monitoring process has begun, the process will continue to be monitored until the data starts to become out of control. If the process becomes out of control, then causes for the variation must be determined, that cause should then be removed, and then the routine tracking process should continue (Madanhire & Mbohwa, 2016). The three most commonly utilized tools from this collection are Check Sheets, Flow charts and Pareto Analysis, while Control Charts are increasing in use. A Pareto chart is a bar graph where the data is arranged by category, then those categories are arranged by the decreasing number of occurrences (Grzegorzewski, 2012).

Many different types of control charts are utilized throughout the manufacturing industry and they are commonly broken down into two different categories, which are variable control charts and control charts for attributes. Variable control charts are used when analyzing a quality characteristic, such as dimensions, height, and weight. The most commonly used versions of these control charts include the $\bar{X}$ and R, as well as the $\bar{X}$ and s charts (Douglas C. Montgomery, 2013b). Attribute control charts focus on processes where numerical values cannot be utilized and products can only be characterized as conforming or nonconforming. Three commonly used charts with different purposes make up this category. They are fraction nonconforming control charts (p-charts), control charts for non-conformities (c-charts), and control charts for nonconformities per unit (u-chart) (Douglas C. Montgomery, 2013a). All of these charts contain the same three key elements, which are the centerline (CL), the upper control limit (UCL) and the lower control limit (LCL). The CL is the target value, while the UCL and LCL are the maximum and minimum limits that are found and set for the process in order for the process to still be considered to be in control (Madanhire & Mbohwa, 2016).

2.4 Summary

The three different topics that were previously discussed, which were *Gemba*, Information Technology and Statistical Process Control (SPC) tools, are fairly new concepts that started to be implemented in the 1970's and 1980's. *Gemba* started its implementation with the lean manufacturing movement and is used to analyze a real process. Information Technology tools are computer systems and electronics that are being utilized in all aspects of life, including manufacturing. Lastly, SPC tools are analysis techniques that are used to monitor and study the variation of a process. These three concepts can be utilized together to monitor and increase various aspects of a process.

Chapter 3: Methodology

The purpose of this research was to create interactive electronic *Gemba* boards and the impact that they have on various aspects of the business. The overall goal of this research is not limited to the creation of these stations to replace the current method of data collection and analysis but also assessing their impact. Three main objectives of this research includes the design and creation of the interactive *Gemba* boards, their implementation into the one department located on the shop floor, and the analysis of the data that was obtained using Statistical Process Control tools and techniques.

The course of this research and project is taking place at a manufacturing facility in the United States. The specific location and name of the facility are omitted from this research to protect proprietary information about the products and processes. Historical information was obtained for the different aspects of the operation that were collected from the displays. As part of this research, the historical information will be compared to the information that is collected using the new displays to establish the impact that this new technique has had on the production, cost, speed, and quality of the process.

This research focuses on combining the Lean Manufacturing tool of *Gemba* with Information Technology and Statistical Process Control techniques. These two additional techniques were used to enhance the effectiveness of *Gemba* in meeting the goals of the organization. Enhancing the existent Gemba boards by creating interactive electronic versions of them will increase the accuracy of the information obtained. This method also creates a strong database of historical data that could be used for future analysis and comparison. In addition, the creation of these displays allows the information that is collected to be stored in a format that

will be easy to analyze by both Microsoft Excel and Minitab. The data obtained after the initial

implementation will be analyzed in Minitab using various SPC tools and techniques.

3.1 Method 1: Electronic Display

The first objective of this research is the creation of electronic displays for data entry and

display on the shop floor. Extensive research has been conducted on the best software to use in

order to create these displays and meet the requirements set for this project. The displays need to

facilitate the entry of data, increase the ease of access to information, and be easy to maintain.

Also, the new displays should present the information in a way that is easy to interpret and met

the original specifications set forth by the company wide *Gemba* board standards. After

examining many different alternatives, it was determined that the best programs to use to

accomplish all objectives of this project were Microsoft Excel and Microsoft PowerPoint, which

were coupled with the use of an add-on application, called DataPoint, that acts as a bridge

between the two programs. The use of the add-on allows the user to set specific refresh times for

the content that is originally found in Excel but is linked and displayed in PowerPoint. Overall,

these software applications were chosen because of the familiarity that the organization has with

the programs, their ease of use, and their graphical displays and data analysis capabilities.

To fulfill the data entry specification for these displays, customized Excel UserForms

have been created for each of the different topics or categories of data. Each of these different

categories has a button, and once that button is pressed, the form for that category is displayed. A

screenshot of the Excel sheet that contains the data entry buttons can be seen in Figure 1.

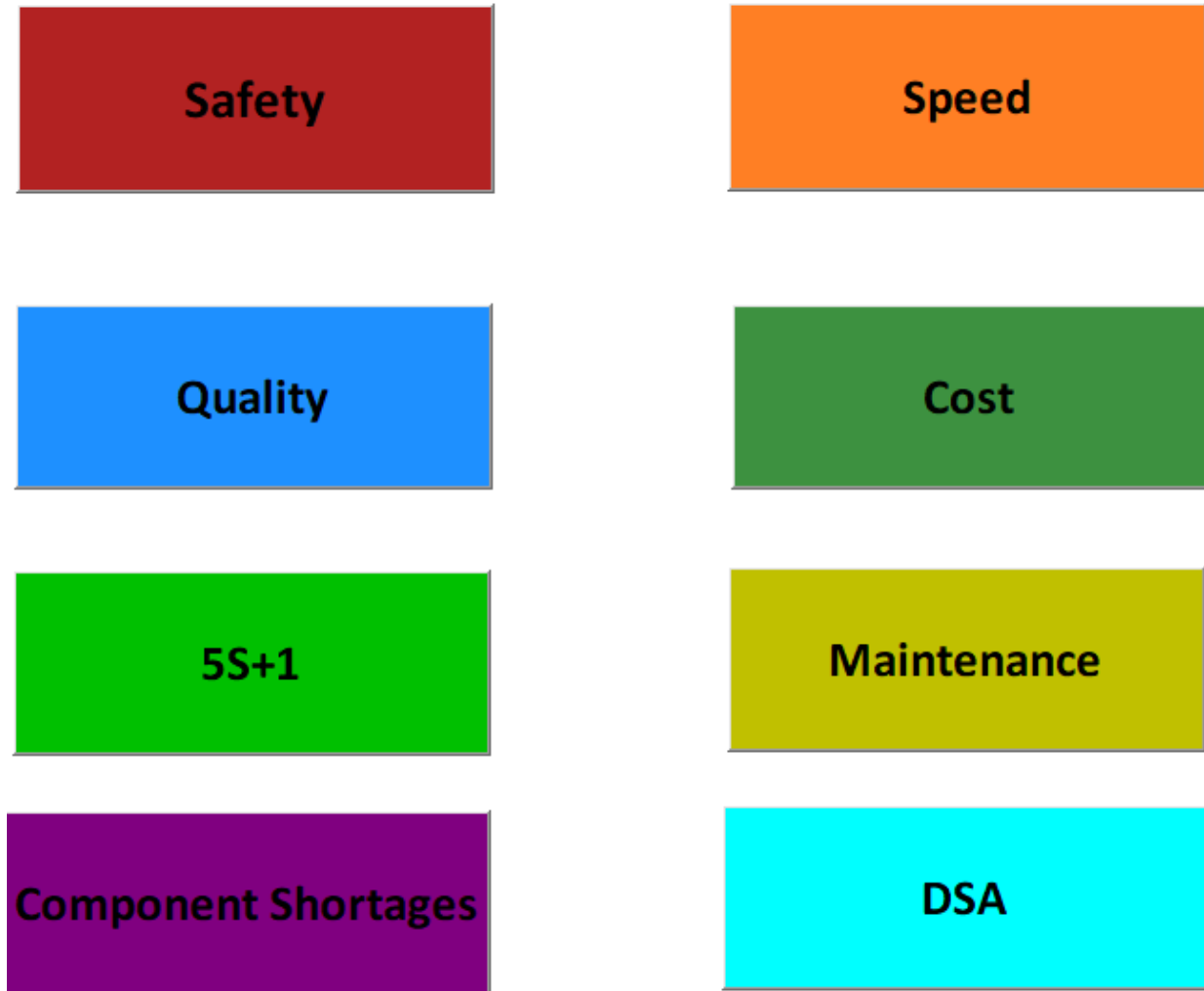*Figure 1: Screenshot of Data Entry Buttons (Created by Researcher)*

These forms are designed so that the user can select the date that the data was linked to from a calendar and then enter the appropriate information. Additional fields are displayed if the data entered meets or exceeds certain limits, such as any goal set by the departments. Figure 2 shows a screen shot of the sequence, specifically for the quality data.
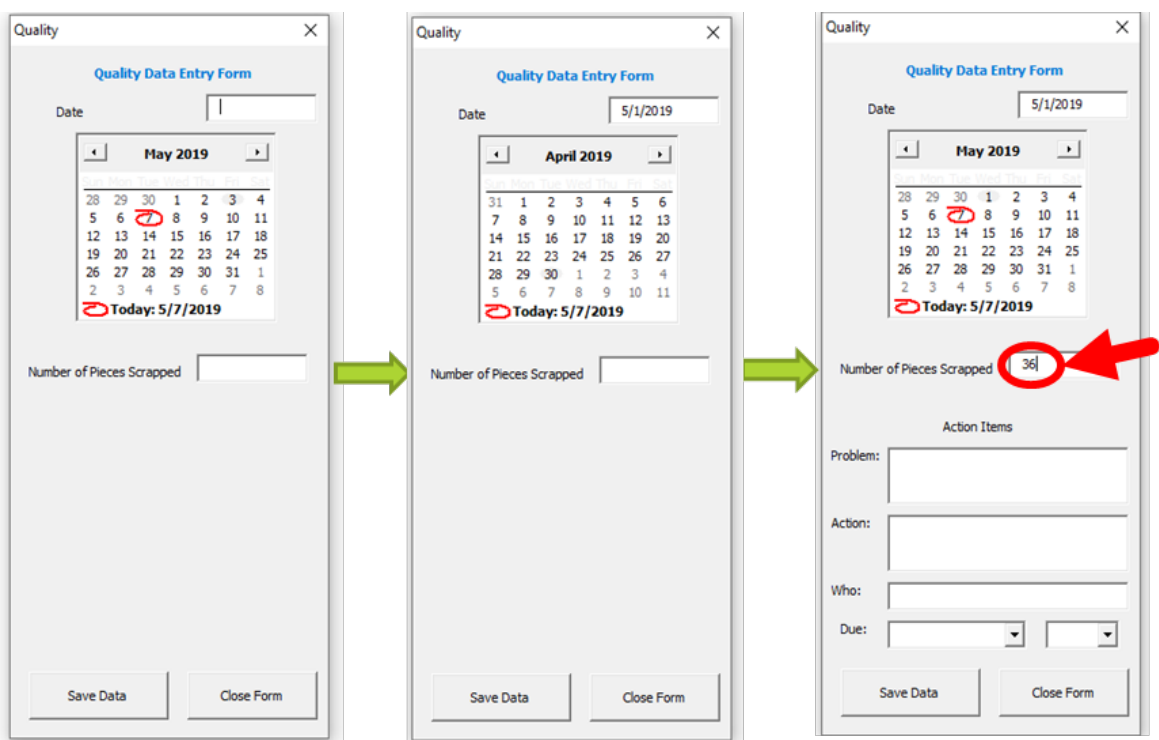
Figure 2: Screenshots of Data Entry Forms (Created by Researcher)

The data that is entered from all the forms is placed into specific columns on an Excel spreadsheet page. That data is then pulled and displayed in other locations and formats using equations and Macros. Figure 3 below shows a screenshot of the Excel sheet that is used to compare and organize the data.

Calendar Month		August	2019	Current Date	9/6/2019	9/5/2019			
First Month of Quarter		July							
		Safety		Quality		Speed		Cost	
		Best Run W/O Incident	400	Goal	15	Goal	10000%	Goal	21.5
		Current Run	400						
Week #	Date	Daily Incidents	Current Streak	Total Scrap		Percentage		Cost	
Week 1	6/30/2019	22	353	#N/A		#N/A		#N/A	
	7/1/2019		353						
	7/2/2019		353						
	7/3/2019		353						
	7/4/2019		353						
	7/5/2019		353						
	7/6/2019	22	353	#N/A		#N/A		#N/A	
Week 2	7/7/2019	22	353	#N/A		#N/A		#N/A	
	7/8/2019	0	354	26		87		27	
	7/9/2019	0	355	24		125		29	
	7/10/2019	0	356	24		136		31	
	7/11/2019	0	357	13		134		46	
	7/12/2019	0	358	16		136		31	
	7/13/2019	0	359	#N/A		49		37	

Figure 3: Screenshot of Excel Sheet Used to Organize Entered Data (Created by Researcher)

Four different calendars have been created to keep track of the data that is entered daily, and this data is color coded to show whether it meets the goals of the department. The screenshot below, Figure 4, shows part of the quality calendar page that depicts the goal and shows the color-coded calendar described previously.

Quality
Goal: 15 Pieces

Number of Nonconformities

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	26	24	24	13	16	
	12	86	16	106	25	
	14	3	0	18	470	
	4	6	491	30	4	

Figure 4: Calendar Located on Gemba Board (Created by Researcher)

The median of the data that is collected each week is also shown on a graph that contains data for the past 26 weeks, and these graphs are created for each of the four categories. The graph compares the median for each week with a line that represents the goal made for each department. An example of the median graph taken from the quality section of the electronic Gemba board can be seen in the screenshot depicted in Figure 5.
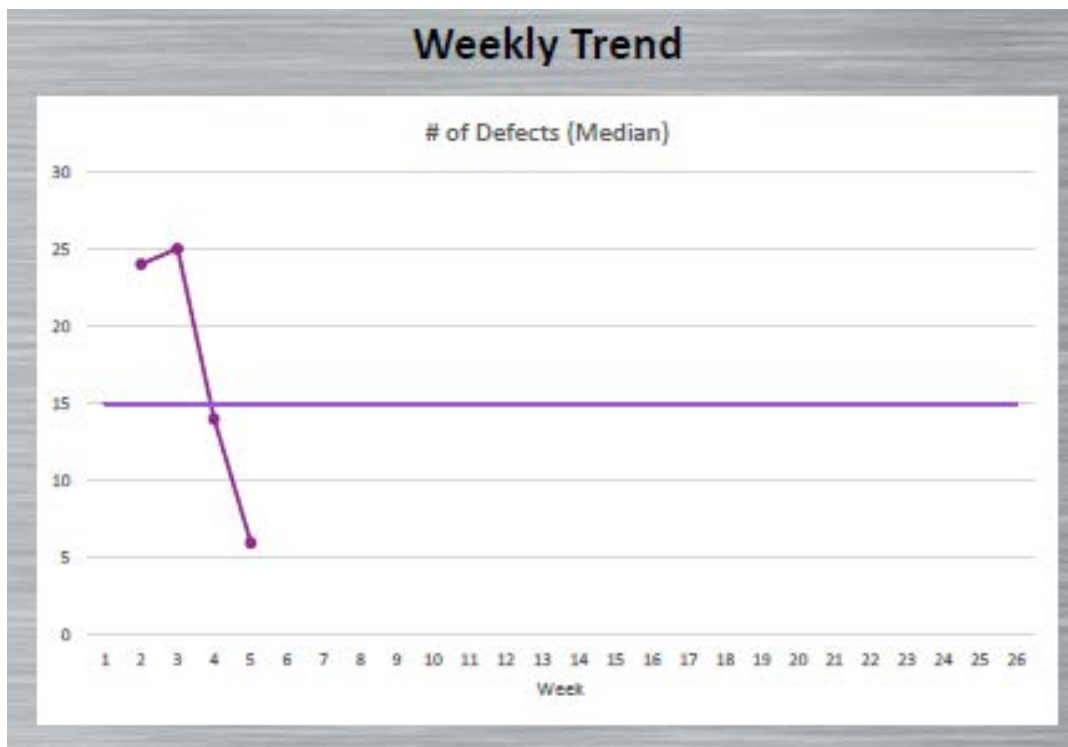
Figure 5: Example of Median Graph Located on Gemba Boards (Created by Researcher)

Pareto Charts for different content, such as scrap reason codes and maintenance hours for different machines, are also generated and displayed. A screenshot of one of the quality Pareto charts can be seen below in Figure 6.
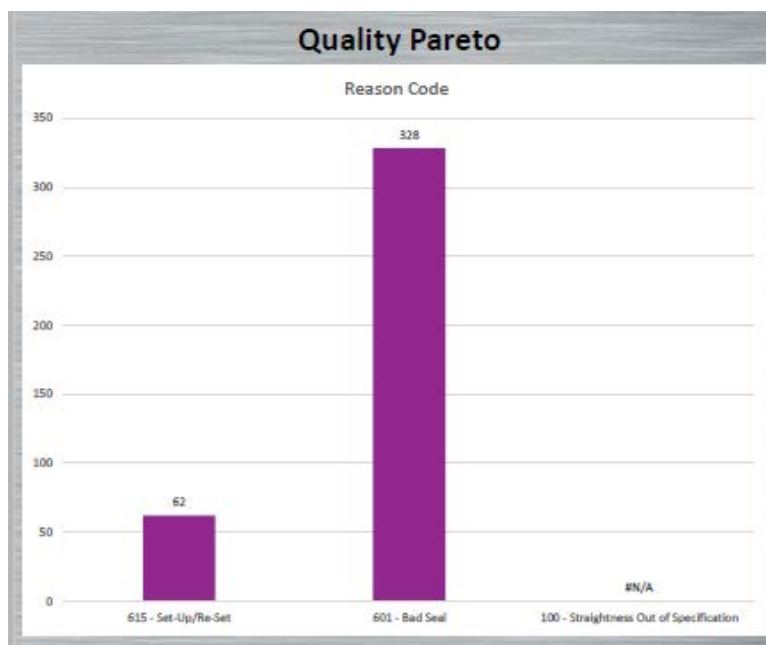

Figure 6: Example of Pareto Charts Displayed on the Gemba Boards (Created by Researcher)

Production information for each shift is also displayed in a standard format that contains the month to date total of production for that department, the average that updates each day, and the difference between the number produced and the goal. A screenshot of the production data can be seen below in Figure 7.

Production
Goal: 3461

DAY	DATE	DAILY	TOTAL MTD	AVG#	+/-
1	8	3220	3220	3220	-241
2	9	4620	7840	3920	918
3	10	5012	12852	4284	2469
4	11	4938	17790	4448	3946
5	12	5032	22822	4564	5517
	13	1808	24630	4926	7325
	14				7325
6	15	4548	29178	4863	8412
7	16	4097	33275	4754	9048
8	17	4085	37360	4670	9672
9	18	3370	40730	4526	9581
10	19	3226	43956	4396	9346
	20				9346
	21				9346
11	22	3297	47253	4296	9182
12	23	3228	50481	4207	8949
13	24	3127	53608	4124	8615
14	25	3008	56616	4044	8162
15	26	2008	58624	3908	6709
	27				6709
	28				6709
16	29	3202	61826	3864	6450
17	30	4369	66195	3894	7358
18	31	2382	68577	3810	6279
19	1	2973	71550	3766	5791
20	2	3565	75115	3756	5895

Figure 7: Screenshot of Gemba Board Production Table (Created by Researcher)

The settings for the Excel document will be altered so that multiple users could access and enter data at the same time.

The data will be collected and organized in Excel and will then be displayed using Microsoft PowerPoint. The presentation file was setup like an app where buttons are designed to

take users to specific pages that displayed the required information. Figure 8 shows the homepage that contains the icons for each of the different information categories, the daily production goal, the month and the number of days the plant is operational that month.

Figure 8: *Screenshot of Gemba Board Home Screen (Created by Researcher)*

The DataPoint add-on is used to set up specific time intervals for the data to update. The PowerPoint settings were also altered so that the only way to change slides would be to use the buttons, and the "click to proceed to the next slide" function was disabled. The hardware that is used are large-scale kiosks that are controlled using an Intel Compute stick, which has access to the network in order to retrieve the required files and information. The kiosks will be locked down so that only the specific files that are used can be displayed and accessed.

3.2 Method 2: Implementation

The implementation of these interactive *Gemba* boards will take place one department at a time, while the old methods will be phased out accordingly. Brief training was offered to the team leaders and necessary personnel who will be utilizing these boards most often. Instructions are posted beside each of the kiosks for how to enter the information and interact with the stations. These instructions will contain screenshots and step-by-step instructions on how to complete the entry process. Additionally, an instruction sheet and checklist for the individuals conducting the monthly updates and data archiving process was created. Also, an announcements page has been created for each of stations that was connected to a designated sheet. An instruction sheet on how to access and update that information was also be created. Lastly, an instruction manual was written to help individuals who would be maintaining and updating the program and files in the future.

3.3 Method 3: SPC and Control Chart Analysis

Once the new information center had been implemented on the shop floor and had been actively been used for three months, the Excel data was examined. The historical and newly obtained data was analyzed and compared using various Statistical Process Control techniques, specifically Pareto and Control Charts. The Pareto Charts were used to examine the different

scrap reason codes that were used; the totals for the monthly graphs were combined and compared to the historic data for a corresponding length of time. Conclusions were drawn on the comparisons of these two graphs to determine the impact of the new data collection technique. Additionally, histograms were used to analyze the cost and speed data that was obtained during the observation period. Lastly, an attribute control chart, specifically the p-chart (fraction non-conforming control chart) was used to analyze the production and quality data that was collected.

Chapter 4: Findings

4.1 Data Collection

The project took place at the request of a manufacturing facility, and because of this, all the data that was obtained and presented in this research has been acquired with permission from the management team at the facility. The primary data was obtained using the information kiosks that were designed throughout the course of this research, as well as the monthly reports that were generated throughout the three-month time period. Four major categories of data were obtained: production, quality, speed and cost.

Production Data

The production data records the total amount of units that are produced throughout all shifts during the course of one business day. The data is gathered from each operator using the production sheets and is then totaled by the department supervisors. This information is then entered into a database that keeps a running total of the number of products produced that month and calculates an average number of parts produced per day that changes daily with the new information that is entered. There is also a section that calculates the difference between the actual number of parts produced to the goal that was set for that month.

Quality Data

The quality data is the number of nonconforming parts that are scrapped throughout the course of a complete business day. The department where this data was collected has a sheet that the operators working in that area are supposed to fill out to specify which component/part, they are scrapping out and at which point in the process it occurred. The sheets contain fields where the operator must include the part number, description, manufacturing order number, the station number where the error occurred, which department or supplier is at fault or caused the issue, the

quantity, the machine or line it occurred at, the reason it is being scrapped and the operator's clock number. The reason that is selected comes from a list of over 100 codes that are located on the back of the form. All of the information that the operators record on these sheets is then entered into the computer system. At the end of each month, a report is compiled where all of the data that is entered throughout the course of the month is listed in a standard format that can be easily analyzed.

An individual examines the sheets mentioned above to determine the totals that are recorded on the boards on a daily basis. The total number of parts and/or components that are scrapped out due to an error or defect that occurred within the department is included in the total. If the error occurred outside of the facility, for example from a supplier, then that defect or component is not included in the total. A pareto chart for the quality data is located on the Gemba boards and showcases the top five reason codes that are used in that department during the course of one month. The totals located on these graphs are updated each day at the same time the daily total is recorded on the calendar.

Speed Data

The speed data is a percentage that is calculated everyday using a standard formula set forth by the company. The calculation is based upon the number of parts produced by that department throughout the course of one business day and the goal that the department has set for themselves. The formula for calculating the speed is the amount of parts produced divided by the goal that was set for that department. That number is then multiplied by 100 to obtain the daily percentage. The goal for this department, as least during the course of this research, was set at the beginning of each month and was always changed at the start of the next month.

$$\textbf{\textit{Speed}} = \frac{Number\ of\ Good\ Parts\ Produced}{Department\ Goal} \times 100 \qquad\qquad \textbf{\textit{Equation 1}}$$

Cost Data

The cost data for each department, which is the output cost per unit per employee hour, is calculated on a daily basis using a set formula provided by the company. The formula first multiplies the number of people that worked in that department across all shifts by the number of hours that each employee worked. The number of parts produced by the department throughout the course of the day is then divided by the product mentioned above.

$$Cost = \frac{Number\ of\ Good\ Parts\ Produced}{(Number\ of\ People) \times (Number\ of\ Hours\ Worked)} \qquad \textbf{\textit{Equation 2}}$$

4.2 Data Analysis

The electronic gemba board was implemented and used for a three-month analysis period and the data that was obtained during that time period was examined and compared to three months of historic data. All the data that was analyzed for this research took place from March 2019 until August 2019 and is broken up into two data sets, pre and post electronic Gemba board. The historical data (pre-Gemba) that was obtained came from March through May of the timeframe listed previously. That time frame was selected because the process would not have undergone any major changes during that period of time, and in addition, the demand and type of products produced during that timeframe would be more consistent. The primary (post-Gemba) or present data was taken from June through August of the time frame initially stated. The three-month range was selected to give users enough time to become familiar with the new technology, as well as giving the researcher time to address any issues or errors that occurred in the early introduction process for the electronic Gemba boards.

4.2.1 Preliminary Analysis

For the historical data, the monthly scrap and production reports for March, April and May were examined. All reports are saved as Excel files containing both raw data and a formatted final version, in which a template is used that was designed by the facility for easy comparison of the data. The historic data was gathered from monthly reports, as well as daily scrap reports, to help remove the unnecessary data from the scrap reports. The present data was gathered from the Excel file where the data entered into the electronic Gemba board is stored. In addition to this information, the reports for pre and post electronic Gemba board periods were pulled in case additional information was needed. The reports contain more details that are not entered into the Gemba board, especially for the quality data. The monthly reports for quality include the type of part, the cost, and the reason each part was scrapped, while the Gemba board just contains the total number of parts scrapped each day. All required data was added to a single Excel file where a tab for each month and type of data was created, and then the data for each category was combined on two separate tabs, one for pre and one for post electronic Gemba board. By looking at the historic and present data both combined and separately a more general and a detailed analysis of the data could be performed.

Once the designated information was gathered, a preliminary summary of the data was conducted. To start the analysis process, the information for the four categories of data (production, quality, speed and cost) was analyzed to determine the amount of days that were over and under the goal set by the department. This information helped to summarize the state of the process before and after the start of the project. The information was obtained by using the conditional formatting option in Excel on each category of data for each month. The summary and comparisons can be seen in Table 1, where the green represents the desired outcome and red

represents the undesired result. The cases where over goal is good, it is colored green and under goal is colored red. The cases where over goal is bad, which is only quality, that portion of the data is red and under goal is green. By examining the table, it is determined that the production and speed data had more days under then over for March and April, but during May the number of days above goal for these categories greatly increased. The number of days above goal increased during May; however, the goal for production decreased that month. A new goal is set at the beginning of the month and is based upon the previous month's achievement of the set goal. If the goal for the previous month was met the majority of the time, then the goal is increased at the beginning of the next month. The goals dropped substantially over the next two months, but the number of days under goal was still over half the month. The production and speed data both had more days under goal than above goal in June, July and August. The highest number of days under goal occurred in June where the goal was set to the highest it had been since start of the analysis period. The next category that was analyzed was cost, which is calculated using the function discussed previously. As a whole, the cost data was always over goal for more than half the month. The three highest over goal amounts occurred in March, July and August. The highest total occurred during July where all of the days recorded were over goal. The last category, quality, had one goal change during the time period of analysis, where the goal was reduced by more than half. For this category, the department aims to be under goal, which means the number of nonconformities that occurs for one day is less than the set goal. If the number of nonconformities is under goal then that means there was a reduction in the number of pieces scrapped. Only one month had more days over goal then under goal, but this was when the goal had been decreased and was also during the vacation season for the company where different individuals were running unfamiliar machines and caused large scrap totals on more

than one occasion. The largest number of under goal days occurred during August, which transpired even with the significantly decreased goal. The present data set shows a significant improvement, where the department was consistently producing less the 15 pieces of scrap each day.

Table 1: Historical and Present Data Over and Under Goal Analysis

Goal Analysis		Production	Speed	Cost	Quality
	Goals:	4,157	100%	20.5	40
March	Over Goal	10	10	19	5
	Under Goal	11	11	2	14
	Goals:	3,895	100%	27.8	40
April	Over Goal	7	7	15	4
	Under Goal	17	17	9	15
	Goals:	3,756	100%	26.8	40
May	Over Goal	14	14	13	7
	Under Goal	5	5	6	12
	Goals:	4,450	100%	26.5	15
June	Over Goal	2	2	11	10
	Under Goal	18	18	9	10
	Goals:	3,461	100%	21.5	15
July	Over Goal	9	9	20	12
	Under Goal	11	11	0	7
	Goals:	3,118	100%	19.4	15
August	Over Goal	6	6	15	4
	Under Goal	14	14	5	18

Note: Green represents the desired result and red represents the undesired result.

The monthly information was then analyzed to determine the median of each category of data for the first three months. The analysis was completed in Excel using the "Median" function on each of the columns that respectively contained the different data types. On the Gemba boards, the median for each week is shown on a line graph in comparison to the goal. The idea behind these graphs is that extreme lows and extreme highs that occur in the data will be canceled out in order to examine the "true" state of the process. The information that was obtained through this

analysis can be found in Table 2. By examining the data, it is determined that in the historical

data only the May median is over goal for Production and Speed, with March only being slightly

below the goal. All months for the Cost data are above the set goals, which is the desired result,

and the Quality data is all located below the goal, which is the object. For the present data, there

was only one month where the Production data was above goal, which was July. There were no

months in that data set where the Cost data was over goal. For the present data set, the Cost data

was over goal every month and the Quality data was always under goal.

Table 2: Median Analysis of Historical and Present Data

Median Analysis				
	Production	**Speed**	**Cost**	**Quality**
March	3924	99%	28	11
April	3648	91%	28.8	16
May	4097	111%	29.9	14
June	3383	81%	26.9	15.5
July	3577	95%	31	17
August	2632	85%	24	4

4.2.2 Production Data

The production data was analyzed first by creating bar graphs for each month with a line

representing the goal for that month. These graphs can be found in Appendix A with each graph

labelled according to the month they represent. By creating these graphs, a visual representation

of data helped to paint a clearer trend in the data for the production goal. The production data

was then entered into Minitab and a Histogram was created by selecting the "Graph" option and

then choosing "Histogram" from the list provided. A graph was created for each individual

month, as well as for both the historical and present data sets as a whole. The monthly

Histograms can also be found in Appendix A. The Histogram was selected to determine the

value that occurred most throughout the examined period. A cumulative frequency histogram

was also used to see where the increase started to occur. The first graph shown below, Figure 9, shows the histogram created for the historical data set. The graph shows that the greatest occurrences were between the 3500 to 5000, which is where the goals are primarily set. The value that occurred more frequently was 3500, which occurred approximately 13 times, which becomes clear in Figure 9.
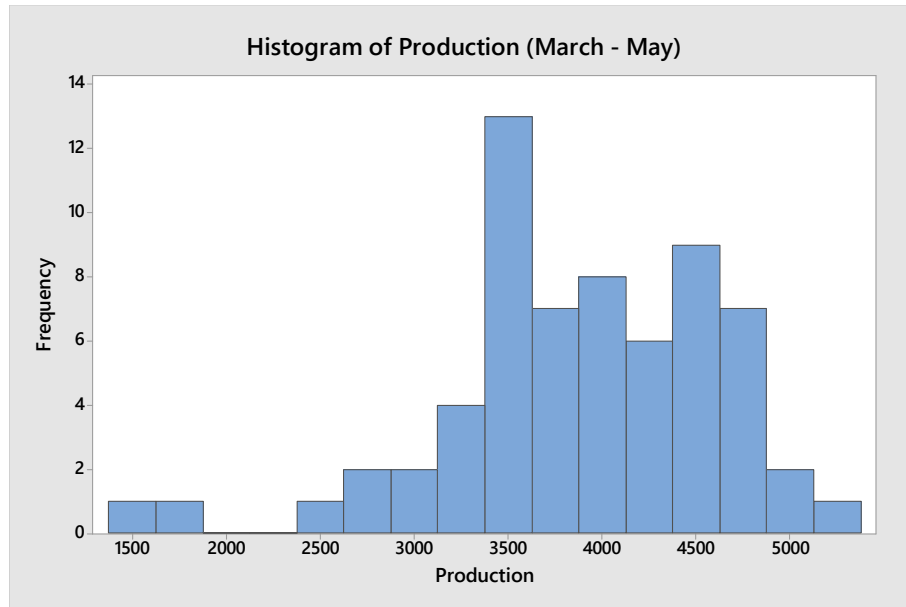
Figure 9: March – May Production Histogram

The graph shown in Figure 10 shows the rapid increase in production once the 3500 data point was reached. The cumulative frequency that is shown on the y-axis of this type of histogram is a running total, where the number of occurrences for a specific value located on the x-axis is added to the number of the previous data entry. Before the 3500 point, there were only approximately 10 days out of 64 days that were below this point. The value was estimated by determining the cumulative frequency value for the production number (located on the x-axis) right before a significant increase occurred.
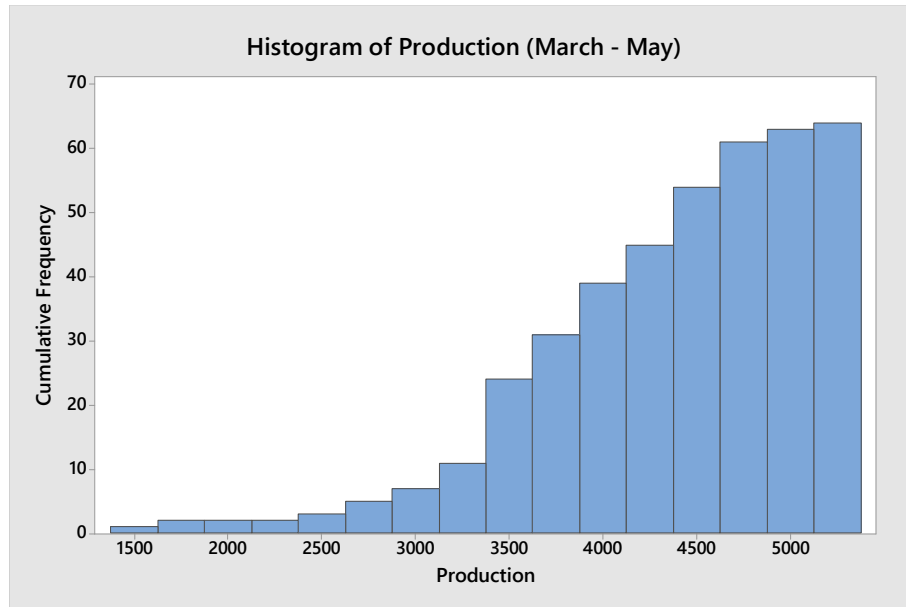
Figure 10: *March – May Cumulative Frequency Production Histogram.*

The primary data set shows a similar trend to it, with the greatest frequency occurring at approximately the 3000 mark where there are approximately 17 occurrences. There is a more centralized pattern for these graphs; especially the graph shown in Figure 11, with a steadier increase and decrease, instead of several sudden spikes, a steadier trend that is occurring in the data is depicted.
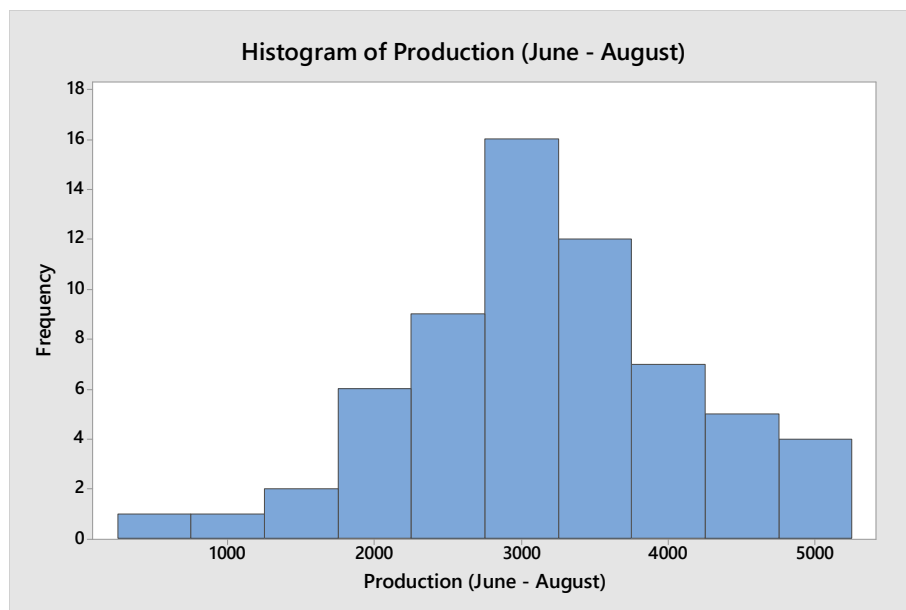
Figure 11: *June – August Production Histogram.*

By examining the information depicted in Figure 12, it can be seen that approximately 15 days out of 63 are under the 3000-point mark, which is slightly less than the historical data previously examined. When comparing Figure 10 to Figure 12 it can be determined that fewer days are located below the 3000-point mark in the historic data set then the current data set. The observation is made by comparing the cumulative frequency value for the production group value that is right before the significant spike in data.
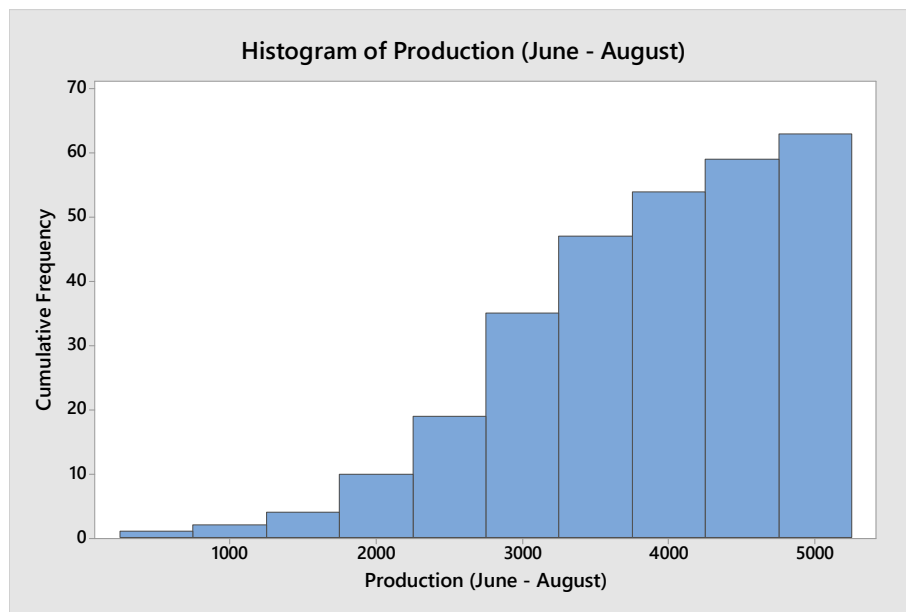
Figure 12: *June – August Cumulative Frequency Production Histogram*

4.2.3 Speed Data

The information pertaining to the speed of the process was analyzed in a manner similar to the production data set. As previously discussed, the speed is a calculated value, which divides the number of parts produced by the goal set by the department. This calculated value is often referred to as the "Say-Do-Percent". The process of examining the data is like the method that was used to examine the Production data.
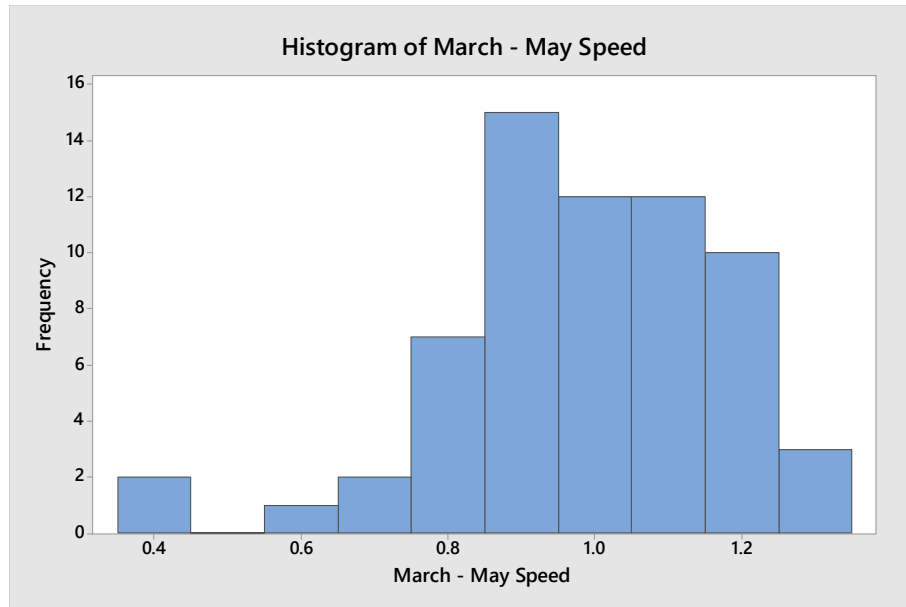
Figure 13: *Histogram of Historic Speed Data*

A histogram of the data is created and depicted in Figure 13. By examining the graph, it can be determined that 15, which is the highest frequency, of the 64 days are at 90% of their anticipated goal. By studying the chart, it is determined that there is a drastic increase in the speed. The data shows that two days were at 40%, then the frequency increases to one day at 60% and two at 70%. After hitting 80%, which has a frequency of seven, the maximum frequency of 15 is hit at 90%, which is still under the goal of 100%. When examining the cumulative frequency histogram shown in Figure 14, only 39 days out of the 64-day period of observation are either on or over the goal.
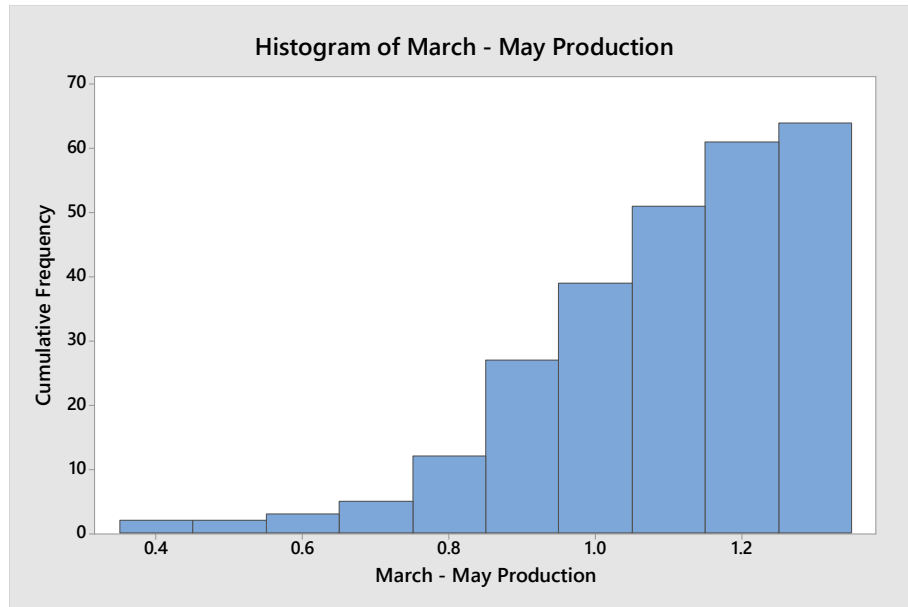
Figure 14: *Cumulative Frequency Histogram of Historic Speed Data*

Histograms for the present data were then created and examined. By examining the graph shown in Figure 15 it can be seen that there is a greater spread in this data then in the previous data set. The data starts at 10% and goes to 150% in a time period spanning 63 days. There were one day totals for 10%, 20%, 30%, and 50%. There was then a spike in the data with the most frequently occurring percentage being 90% at 16 days, which is greater than the historic data set. The present data set also has three days at 130%, two days at 140% and one day 150%, while the largest percentage in the historic data set is 130%. The spread of data for the present set is significantly larger than the historic data, which means production was not running as consistently.
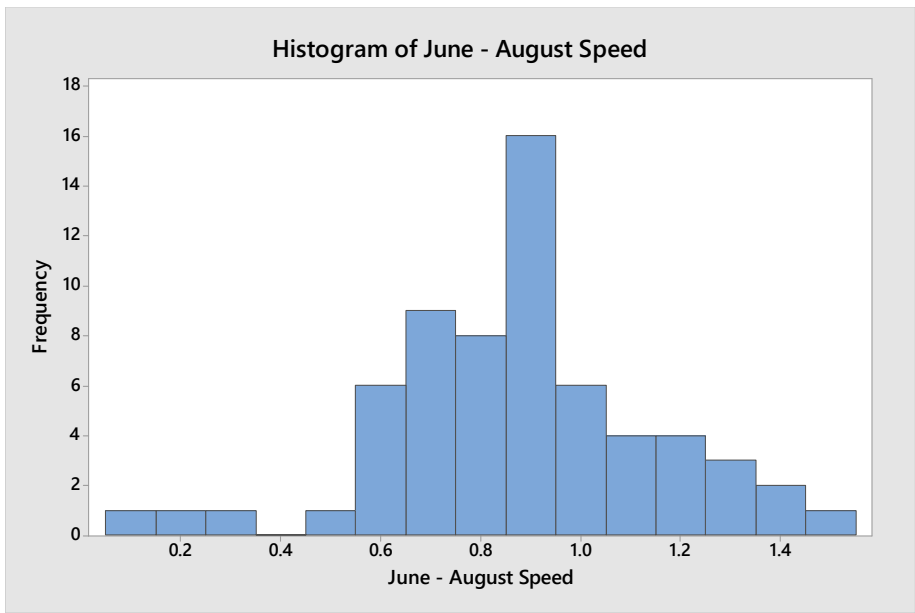
Figure 15: *Histogram for Present Data Set*

When examining the cumulative frequency histogram shown in Figure 16, it becomes clear that

18 days were at or above goal. This is approximately half the number of days that were at or

above goal in the historic data set. Overall, there was more variability in the present data, which

can be contributed to a drop in orders and a decrease in the amount of individuals working in the

area due to vacation time.
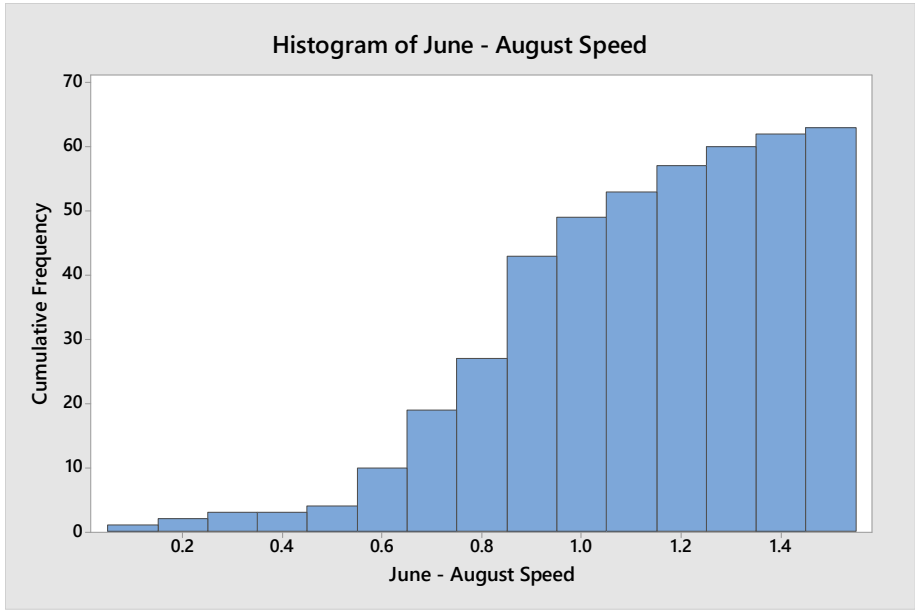
Figure 16: *Cumulative Frequency Histogram for Present Data Set*

The bar graphs and histograms created for each individual month in the six-month analysis time frame can be found in Appendix B.

4.2.4 Cost Data

The next data set that was analyzed was cost, which is the output measured in units per employee hour. As mentioned earlier in this section, this value is calculated using a function set forth by the company, where the number of parts that are produced is divided by the product of the number of people who worked in that department and the number of hours worked that day. To begin the analysis process for this data category, Excel was used to create bar graphs with a line to represent the goal. These graphs were used to analyze the data for each individual month, since a new goal is set at the beginning of each month. Then the software, Minitab, was used to create histograms for each month, as well as a graph for the historic and present data set as a whole. The bar graphs and histogram for each month can be seen in Appendix C.
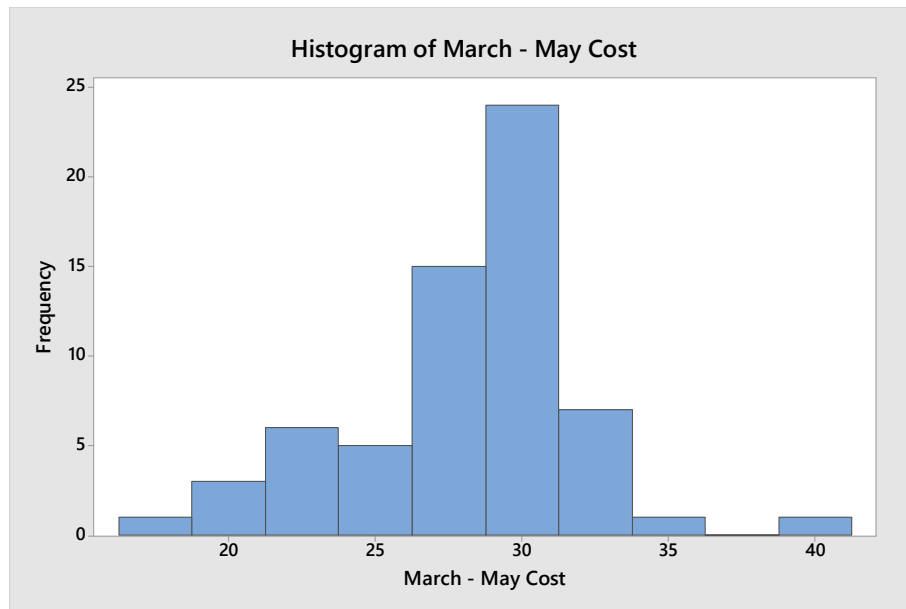
Figure 17: Histogram of Historic Cost Data.

The historic data shown in Figure 17, which is from March to May, was analyzed first with $17.25 being the lowest quantity and $40 as the largest amount. The largest frequency for this

data set is approximately 24, which is at a cost of $30. The second frequency has 15 days total at a cost of $27.5. Both costs are above all three goals that were set during this time period. Overall, a total of 53 days was recorded as being over goal by examining the cumulative histogram depicted in Figure 18.
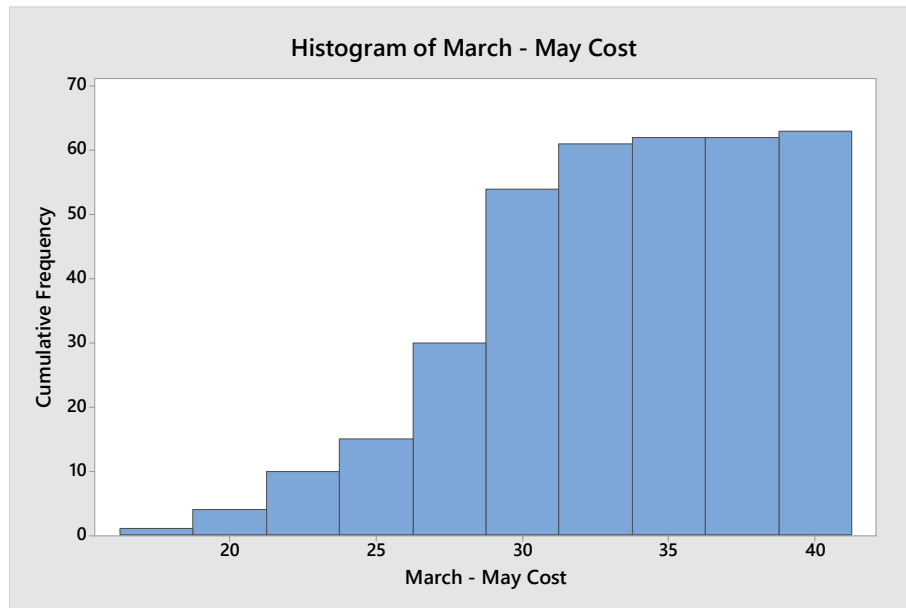
Figure 18: *Cumulative Frequency Histogram for Historic Data Set.*

Then, the present data set was examined using the same process, the histogram can be seen in Figure 19. The span for this data set, which is from $7.5 to $40, is significantly larger than the historic data set, which spans from $17.5 to $40. The grouping for this data set is significantly tighter than the previous three months with the grouping starting at $22.5 to $32.5. Even though the span is greater than the previous data set, all of the information outside of the tight grouping has a frequency that is less than 3 days. The greatest frequency, which is 16 days, occurs at $27.5, which is 8 days less than the historic data set.
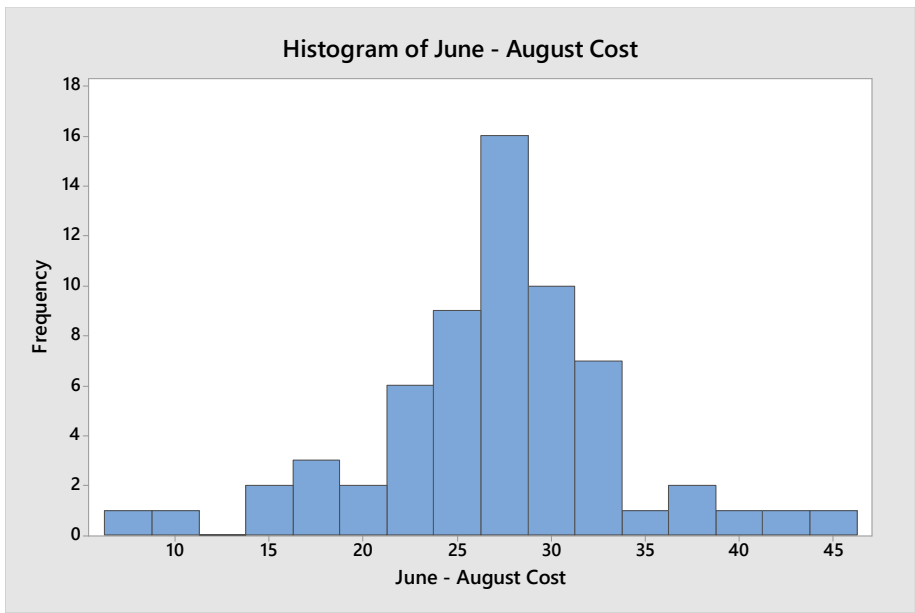
Figure 19: *Histogram of Present Cost Data*

By examining the cumulative frequency histogram shown in Figure 20, it shows that

approximately 63 days are above goal, which is the same as the historic set. Overall, the cost data

has remained consistent throughout the entire six months of observation.
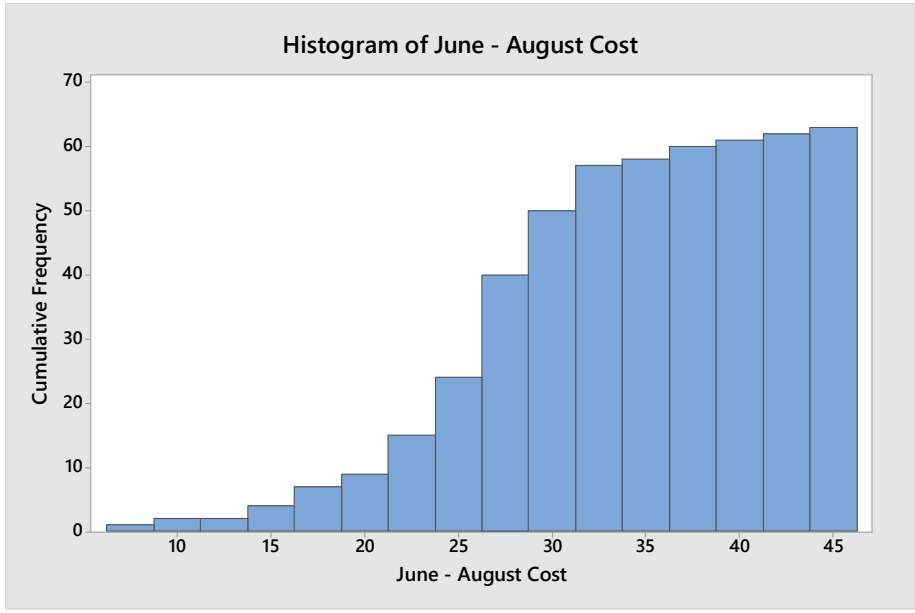
Figure 20: *Cumulative Frequency Histogram for Historic Data Set*

4.2.5 Quality Data

Before the quality data was analyzed, certain categories of data were removed from the historic data set, specifically the pieces that were scrapped during the rework process and the nonconforming pieces that were scrapped due to a cause attributed to a supplier. These two factors are not included in the Gemba board totals because rework is not completed on a regular/daily basis and the foundry scrap is not charged to the department.

The quality data is analyzed using several different techniques, the first being an Excel Pivot table that was used to calculate the total quantity and cost of each of the different reason codes used throughout the department that is being analyzed. The table shown below, Table 4, shows the information that was obtained by completing this process for the historic data set. The total cost was added to this analysis, instead of just the total pieces that were included on the Gemba board, because the cost of the items varies drastically. For example, only 15 pieces were scrapped because they cracked during the manufacturing process, but the total cost was more than that for the 144 pieces that were scrapped because the wrong component that was used. When something cracks during the process it is typically the Inner, Outer or possibly the Retainer, which are more expensive parts than seals, which is typically the part that is scrapped for "Wrong Component". In the department that was analyzed from March through May the most common reason for scrap, in both the number of pieces and the total cost, was "601-Bad Seal" with over 2,992 pieces adding up to $1,164.26. Overall, 3,513 nonconforming pieces were scrapped adding up to over $2,052.50 in costs.

Table 3: *Summary of Scrap Reason Code Totals for Historic Data Set*

Reason Code	Quantity	Total Cost
1. 601 Bad Seal	2992	$ 1,164.26
2. 202 Cracked	15	$ 312.28
3. 824 Wrong Component	144	$ 185.07
4. 506 Insert/Wrong Component	75	$ 96.93
5. 604 Inspection Set-Up Error	41	$ 86.79
6. 406 ID Undersized	31	$ 74.03
7. 615 Set-Up/Re-Set	24	$ 64.07
8. 828 Bad Radius	10	$ 27.55
9. 100 Straightness Out of Spec	152	$ 20.60
10. 505 Insert/Reversed Outer	4	$ 9.36
11. 835 Surface Finish	6	$ 7.89
12. 507 Insert/Missing Rivets	16	$ 2.77
13. 504 Insert/Incorrect Marking	1	$ 0.55
14. 503 Insert/Bad Retainer	2	$ 0.35
Total	**3513**	**$2,052.50**

A Pareto chart was also created using Minitab to illustrate the total and the relationship between

the reason codes. The chart shown in Figure 21 depicts that 85.2% of the scrap that was

generated during the historic time period was due to the "601 – Bad Seal" reason code. All of the

other reason codes documented in the department only make up 14.8%, with the next highest

percentages being 4.3% and 4.1%. These factors support the observation that "601 – Bad Seal" is

the largest contributing factor to scrap.
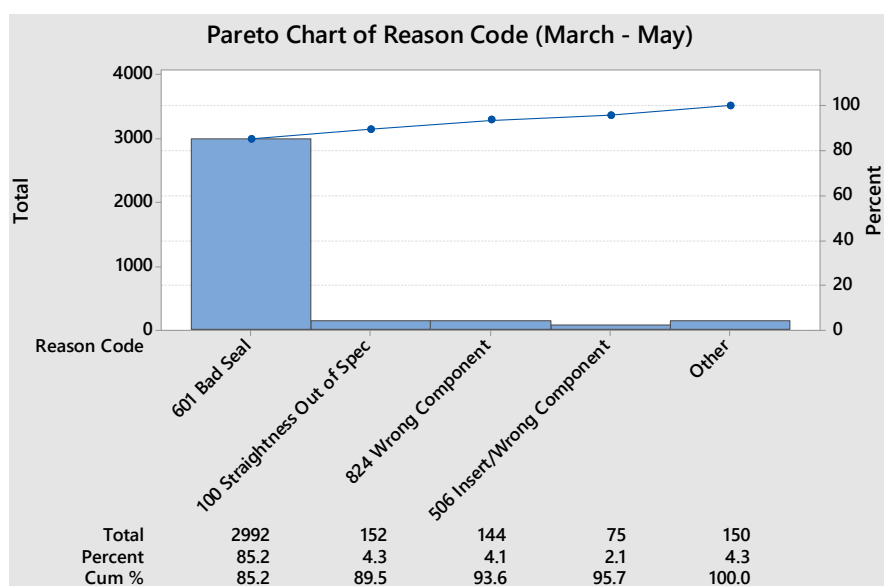
Figure 21: *March – May Scrap Reason Code Pareto Chart.*

The present data, which was collected from June through August, was analyzed using the same method. The information shown in Table 4 shows that the largest factor for scrap was also "601 – Bad Seal" with a total of 1,366 pieces scrapped adding up to a total of $1,719. Over the three-month period a total of 1,682 pieces were scrapped from this department, which adds up to be $2,415.64. There were 1,831 fewer pieces scrapped during the present data set when compared to the historic data set, however the total cost is $363.14 greater than the previous historic data set. As mentioned earlier in this section, the prices of pieces that were scrapped can vary wildly which becomes very apparent when analyzing the top reason codes.

Table 4: *Summary of Scrap Reason Code Totals for Historic Data Set*

Reason Code	Quantity	Total Cost
1. 601 Bad Seal	1366	$ 1,719.50
2. 604 Inspection Set-Up Error	114	$ 196.84
3. 406 ID Undersized	35	$ 119.65
4. 514 Lasering	18	$ 62.94
5. 824 Wrong Component	31	$ 53.36
6. 615 Set-Up/Re-Set	18	$ 51.35
7. 505 Insert/Reversed Outer	1	$ 49.81
8. 825 Hole Location	3	$ 39.91
9. 202 Cracked	1	$ 31.95
10. 501 Insert/Tight Fit	7	$ 19.39
11. 503 Insert/Bad Retainer	12	$ 17.08
12. 835 Surface Finish	10	$ 16.65
13. 832 Missing Operation	12	$ 16.06
14. 303 Bad Coating	5	$ 15.07
15. 100 Straightness Out of Spec	39	$ 3.19
16. 836 Rivets	10	$ 2.90
Total:	**1,682**	**$ 2,415.64**

The pareto chart, shown in Figure 22, was created using the same process that was utilized for the historic data set. By examining this data set, it was determined that "601 – Bad Seal" makes up 81.8% of the total amount of pieces scrapped, while the second highest reason code, "604 – Inspection Setup Error" makes up 6.8%. The top reason code is the same in both data sets, however the second reason code in the present data set "604 – Inspection Setup Error"

being number five on the list with only 41 pieces being scrapped compared to 114 scrapped in

the second data set. Overall, the total number of pieces scrapped drop by over 1,000, which was

a great improvement when considering the fact that there were several large scrap days during

July and August due to operator changes. The total cost did increase, but that can be attributed to

the increase in setup scrap, which relates to the higher cost pieces being scrapped out early in the
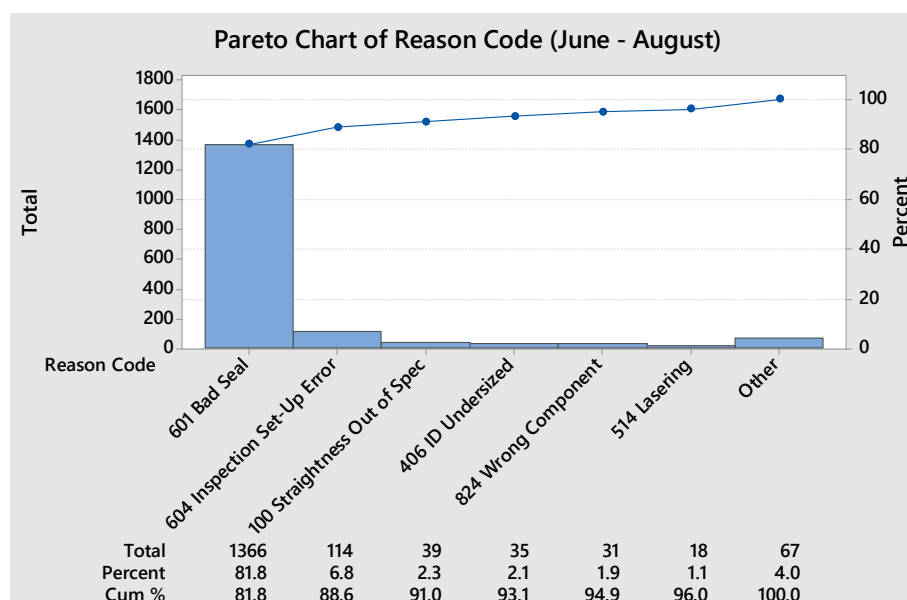
process.

Figure 22: June – August Scrap Reason Code Pareto Chart

4.2.6 Process Analysis

The last category of data that was examined is the process itself. To determine the state of

the process before and after the introduction of the electronic Gemba board, an attribute control

chart for the fraction of parts that were nonconforming, also known as a P-chart, was used. A

fractional nonconforming control chart is a ratio of the number of nonconforming items

produced to the total number of items produced. For this type of analysis, the parts examined can

be considered nonconforming if they have one or more defects. At this facility there are specific

reason codes used to scrap parts and the computer system that is used to keep track of the

number of nonconformities can only accept one reason code per part number. Once one of the

reason codes appears on a part then the unit is scrapped. The scenario and procedures used at this

facility fit the requirements and specifications needed in order to utilize this type of attribute

chart.

To create these charts the software, Minitab, was used to analyze the data. The number of

nonconforming products produced per day was used as the variable and the production amount

produced was the sample size. The software automatically calculates the centerline (CL), upper

control limit (UCL) and lower control limit (LCL) for the data set that is entered. The formula

used to calculate the centerline ($\bar{p}$) can be seen below, where m is the number of days, n is the

number of parts produced per day, and D_i is the sum of nonconforming parts.

$$\bar{p} = \frac{\sum_{i=1}^{m} D_i}{mn} \qquad\qquad \textbf{\textit{Equation 3}}$$

The value of $\bar{p}$ is then used to calculate the upper and lower control limits using the equations

listed below.

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \qquad\qquad \textbf{\textit{Equation 4}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \qquad\qquad \textbf{\textit{Equation 5}}$$

The P-Chart for the historic data can be seen below in Figure 23, where there are nine

days that are above the upper control limit. The sample sizes vary because the number of parts

produced per day was not a constant value, so because of this the three values are calculated

based upon the criteria for each day. That is why the limits shown on the graphs are the averages

of the calculated values for each of the days. The calculated average UCL for this data set was

calculated to 0.0195, the average for the centerline was calculated to be 0.0140, and the average

for the LCL was determined to be 0.0084. The graph in Figure 23shows that many of the days

are below the LCL, which is an indication of a process in good control, where oftentimes this value can be zero. The red indicators for the lower control limits just indicate that the process is not as consistent and is performing better than the value determined using Equation 5. To summarize the historic data process, there were a total of nine days that were above the UCL and only five days where the process fell within the statistical control limits.
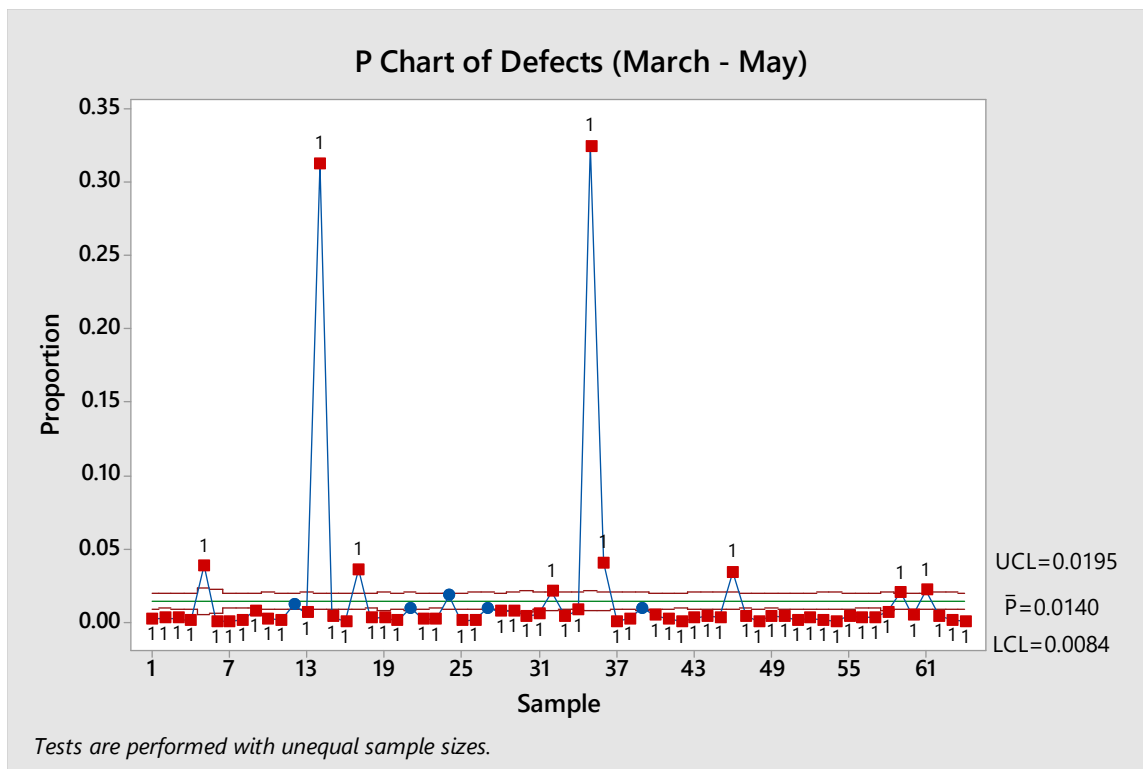
Figure 23: March to May P-Chart for the Process

The P-Chart for the present data set is shown in Figure 24, where the average upper control limit was 0.0165, the average centerline 0.0099 and the average lower control was 0.0033. The limits for this data set are lower than those calculated for the historic data set. Overall, a total of eight days was above the UCL and there were 18 days that were within the calculated limits. When comparing the two different data sets, the present data set has fewer datapoints over the UCL, as well as more points within the calculated limits. Though there are more datapoints above the limit in the present set, there were three points that were right on the

UCL line. Since the UCL was lower in the second set and these points were right on the line they could be excluded in the comparison between the sets, which leaves five points above the limit. In conclusion, the present data set shows that the process is statistically in greater control then the historic data set.
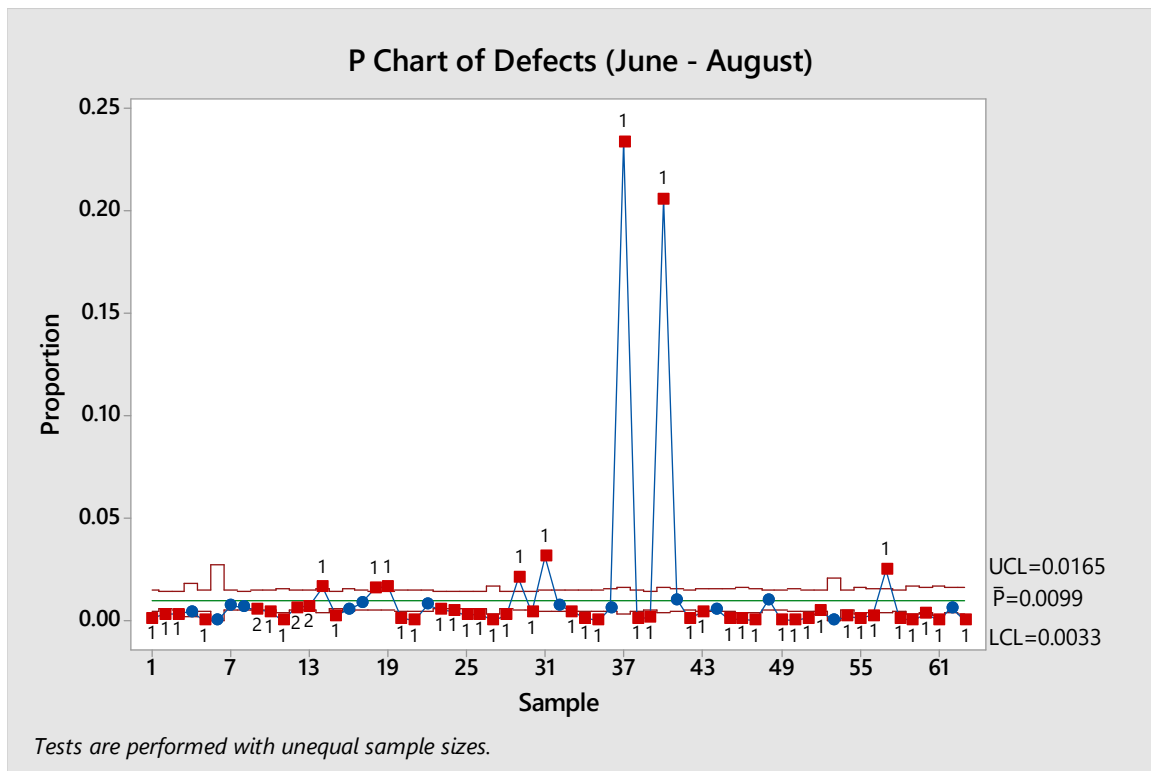
Figure 24: June to August P-Chart for the Process

4.3 Comparisons

When analyzing the two different time periods there are certain factors that must be taken into consideration. One is that during the second time period that was observed, there was a noticeable drop in the demand for certain products, which impacted the number of units produced. This factor in turn caused the number of products that were produced to drop, which had an impact on the production, speed and cost per output unit. Second, there were several different large scrap occurrences during the summer months in the present three-month data set, which was due to different operators taking time off and the individuals covering those tasks

incorrectly operating the equipment. These differences help to explain some of the differences that appear in the primary data set, as well as some of the spikes in the scrap amounts.

4.4 Testimonials

The creation of the electronic Gemba board was done at the request of a company who wanted to incorporate more information technology into their facility and process. The feedback on the project was very positive and the management team of the company was pleased with the results.

After the technology had been implemented at the facility for several months, different members of the department and management team were questioned about their experience with the boards. The High Energy Team Leader for the department being observed said that the new boards are easier to use and that he prefers it to the previously used whiteboard method. The team leaders must discuss and expand upon the information that is displayed on the Gemba board during the Gemba walks. The individual said that explaining the information displayed on the electronic board was easier to talk about and explain because it is more legible and neater than the other method. He also mentioned that no one can change or alter the data that is entered using the new method, which contrasts drastically with the old method where anyone could use a marker to change or alter the information. Another feature that was also mentioned was that the data is more accurate for several reasons, such as the legibility and security of the data, as well as the fact that some of the information is pulled directly from the source, which prevents altering, or misinterpretation of data.

A member of the management team was also questioned about the new electronic Gemba board, where he talked about how they have improved the Gemba walk and discussions in that area. The area where this project took place is the only area in the facility where the board is

completely updated and maintained by department team members. The other boards are primarily updated by the area supervisor and the department team members state the data that can be seen on the board, but do not elaborate or explain what is documented. The author of this research attended Gemba walks in all areas of the plant and it seemed that the individuals in the area where the new board was implemented was more invested in the information and process. They expanded on the information shown in greater detail, as well as provided explanations and background information about any spikes or dips within the area. The discussions that happened in this area were more precise and the switching between topics flowed more smoothly. Also, more information seemed to be gained and discussed in a shorter amount of time. Lastly, when analyzing the data, it was determined that the data that was obtained during this time frame was significantly easier to analyze due to the format and the centralized location where the data was stored.

Chapter 5: Conclusion and Recommendations

5.1 Summary

Lean manufacturing practice started in the early 19th and was developed into the early 20th century with the purpose of eliminating waste and providing the best product possible for customers at the lowest possible cost. The major advantage of this method is that it provides companies with a competitive edge that is produced by improving overall productivity and quality in addition to reducing the cost of products. Lean manufacturing techniques both heavily rely on and incorporate quality control tools and methods. Quality is the fitness of a product for its intended purpose, and quality control systems are created to ensure that the products and standards set forth by the management of the company are met. A common lean manufacturing tool that is used to accomplish the desired objectives is gemba, which is a Japanese term meaning go and see. The objective of this tool is to have upper level management of a company go to the shop floor to gain a better understanding of the different aspects of the business. The purpose of this research was the creation of interactive Gemba boards and the assessment of their impact on major aspects of the business.

The goal of this research was to create interactive electronic information centers to replace the current method of data collection and analysis, which consists of printed dry erase boards. The electronic gemba board was implemented and used for a three-month analysis period and the data that was obtained during that time period was examined and compared to three months of historic data. The historic data was gathered from monthly reports, as well as daily scrap reports, to help remove the unnecessary data from the scrap reports. The aspects of the production system that were analyzed were production, speed, cost, quality, and the process as a

whole. The data was analyzed using different SPC techniques and tools, and the information that was analyzed for the two time periods was then compared.

The project took place at a manufacturing facility at the request of the management of that facility, who wished to incorporate information technology into their process and day to day operations. The data for this research was obtained with permission from the management team at the facility. Throughout the course of this research, there were three different objectives, namely the design, implementation of the electronic Gemba boards and analysis of the data gathered at the plant. These objectives were met.

Objective 1: Design and creation of interactive Gemba boards based upon company criteria and suggestions.

The company wanted the operators to be able to use these displays like terminals where they could update and enter the information from these locations. The data that was entered needed to be altered so that it was displayed in the company's required format. Another stipulation was that the system needed to be easy to use and maintain by individuals without an extensive knowledge of computer programming languages. Extensive research was conducted on the best hardware and software to use in order to create these displays. For the hardware aspect of this project, free-standing large-scale kiosks that are powered by an Intel Compute stick and operated using a Bluetooth keyboard with a built-in mouse pad were chosen. To meet the interactive requirement of the display a software with good graphics and an interactive interface needed to be chosen, while a data analysis software needed to be utilized to examine the information. Based on the software that was commonly used by the company and the employees' familiarity with the Microsoft Office Suite, it was determined that Microsoft PowerPoint and Excel would be used. To combine the necessary aspects of both software a PowerPoint add-on

called DataPoint was used as a bridge between the two programs. The bridge allows the data shown in the presentation to automatically update and mirror the information shown in Excel. Using macros and VBA programming language UserForms were created for each of the different data categories to help with the process of adding and updating the data.

Objective 2: Implementation of the new Gemba boards into one of the departments and the shop floor.

The kiosk was implemented in one department and the data was collected for three months. The initial implementation happened in June, where the researcher completed an extensive troubleshooting process. During the initial implementation period, several adjustments needed to be made at the request of the High Energy Team Leader of the department and the upper management of the company. The adjustments that were made focused on improving the layout of the system, the speed and flow of the transitions between topics and the order in which the data was displayed. Training was given for the team leaders and supervisors for each of the shifts overseen by the department. A checklist about which aspects, such as the date and the file that the data was pulled from, need to be switched and updated at the end of certain time periods, such as the end of the month, was created. Also, a manual of approximately 100 pages was created that contained instructions, as well as screenshots, on how to update different aspects of the board, how to add new elements, manage the data that was entered, and how to handle the most common errors that occurred.

Objective 3: Analysis of data obtained by the interactive display using statistical process control charts and other quality control tools and techniques.

Analysis was conducted on five different aspects of the business, i.e. production, cost, speed, quality, and the process. Two different programs, Microsoft Excel and Minitab, were used

to analyze the data from both the historic and present data sets for each of the different types of data. For the production, cost and speed data bar charts for each month were created as part of the preliminary analysis. Then histograms and cumulative frequency histograms, both for each individual month and the two different time periods as a whole, were used to analyze the data and detect trends or patterns. The comparison for the production data showed that the present data had a slightly lower production number for the most frequently occurring value. The speed data showed more variability then the historic data set, which can be contributed to a drop in orders and a decrease in the number of employees that were working during the time period due to vacations. The cost data remained consistent throughout the entire six-month observation time period. The quality data was organized based on the reason code that was used to scrap the part and was analyzed using a pareto chart. A comparison between both data sets revealed over 1,000 less pieces were scrapped during the present data set than the historic data set, even taking into consideration the large scrap occurrences that happened during that time period. The total scrap cost did increase, but that can be attributed to the increase in setup scrap, which relates to the higher cost pieces being scrapped out early in the process. The last data set that was examined was the overall process capability which was analyzed using a P-Chart, which is a fraction nonconforming control cart. When comparing the P-chart for both time periods it was concluded that the present data set is statistically in greater control than the historic data set.

5.2 Conclusions

The primary purpose of these gemba boards was to create a new method for the display and analysis of data. The new method allowed for easier access to data, a larger database of historic data and a standard format for all of the stored data. The information that is archived at the end of the month makes it easier to determine patterns in the data. From the researcher's

experience gathering data, both pre and post implementation, the present data was much easier to analyze then gathering data from past monthly reports. The management of the company and the High Energy Team Leaders in the department that was analyzed were both impressed with the new technology. The team leaders commented on how the data was easier to read, in addition to being more secure and accurate since only certain people had access to the data to alter it once it had been entered into the system. The management team expressed how this is the only department where the all of the data is maintained and added by the department team members, which helps the team members feel more invested in the data. Also, the new method has created better flow for the gemba walks and have helped to provide more detail to the discussions that take place.

After completing all three objectives, the researcher determined that the gemba board had not been implemented for a long enough period of time to see a significant impact on the different aspects of the business. From the data, it was determined that the aspects of the business that had seen the greatest changes since the initial implementation were the quality, cost, and process. The decrease in the production and speed data can be contributed to the decline in orders that started to occur during the three months that made up the present data set.

5.3 Limitations and Recommendations for Further Study

To establish if the electronic gemba board has a more definitive impact on the company a greater time period should be examined. The department where this research took place went through significant restructuring, which resulted in the department changing from a two to a one shift operation. If further research was to be done, the best option would to be to start when another gemba board is implemented into a department. A time period greater than three months should be examined, and this researcher recommends a minimum of six months although a

whole year of observation would be preferred. The same time span of historic data from that same department would need to be examined as well to determine the extent of the impact that the new technology had on the company.

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Appendix A: Production Analysis
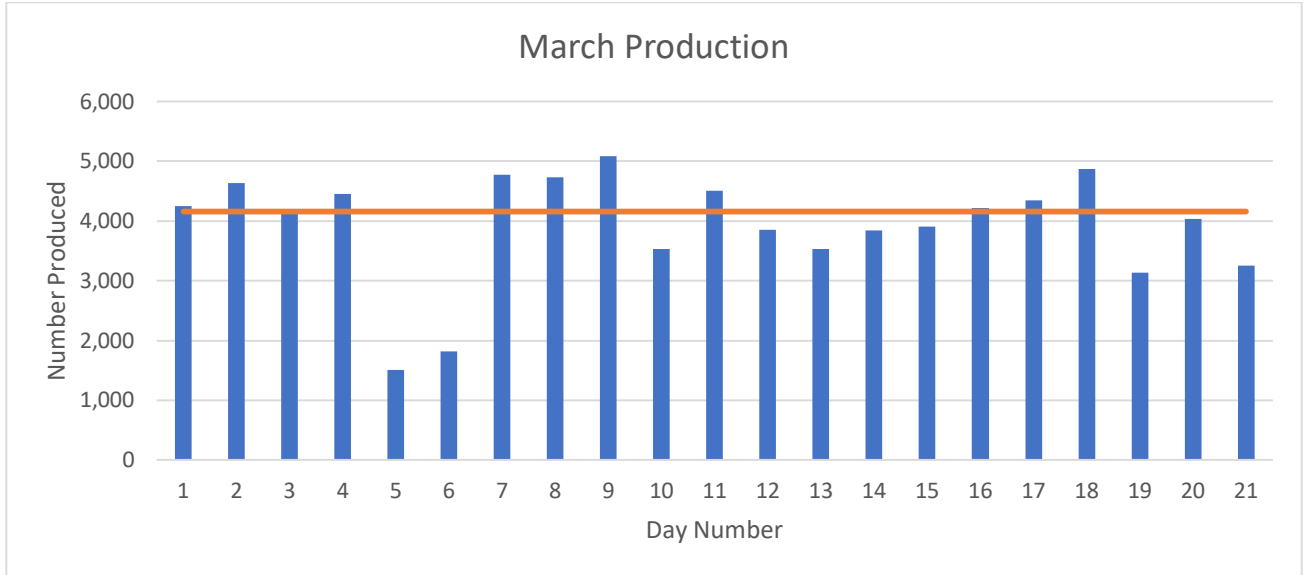
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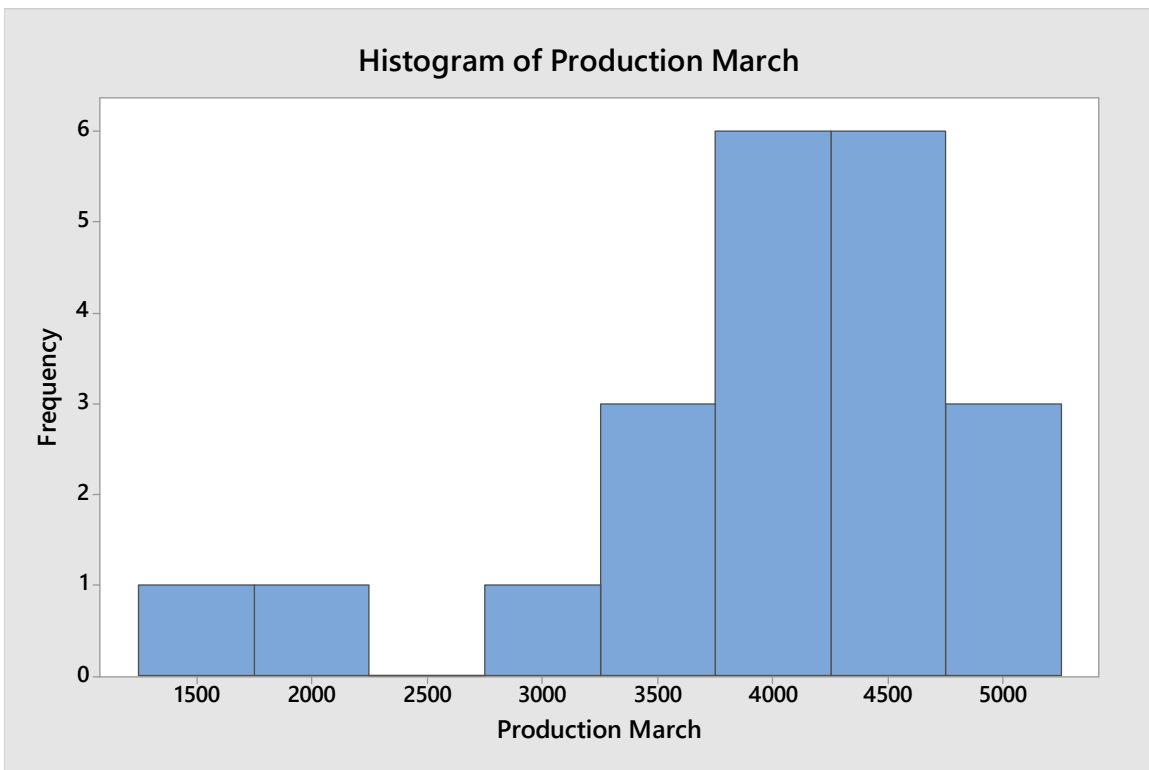
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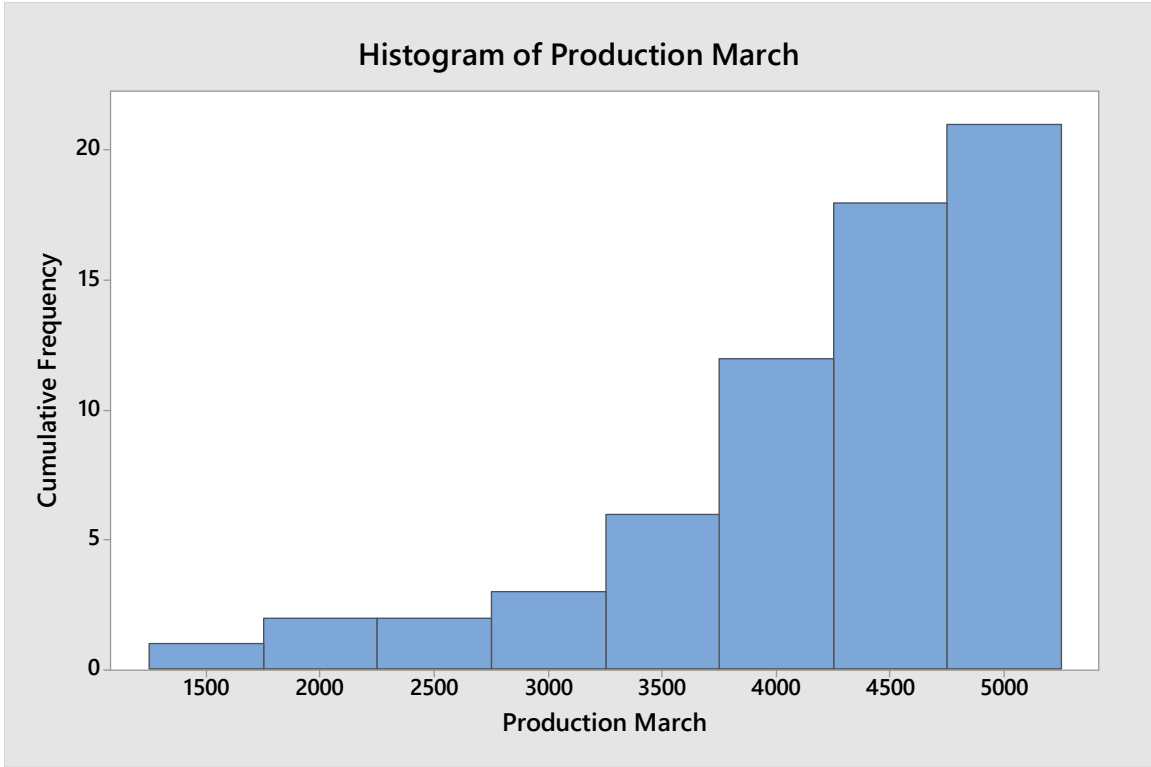
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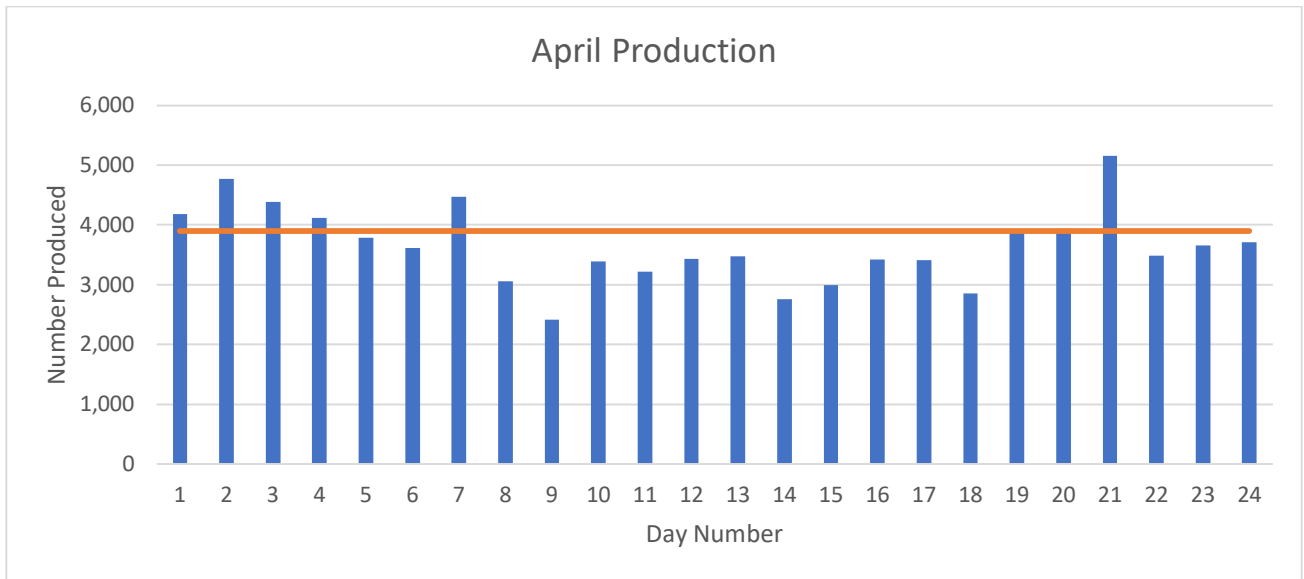
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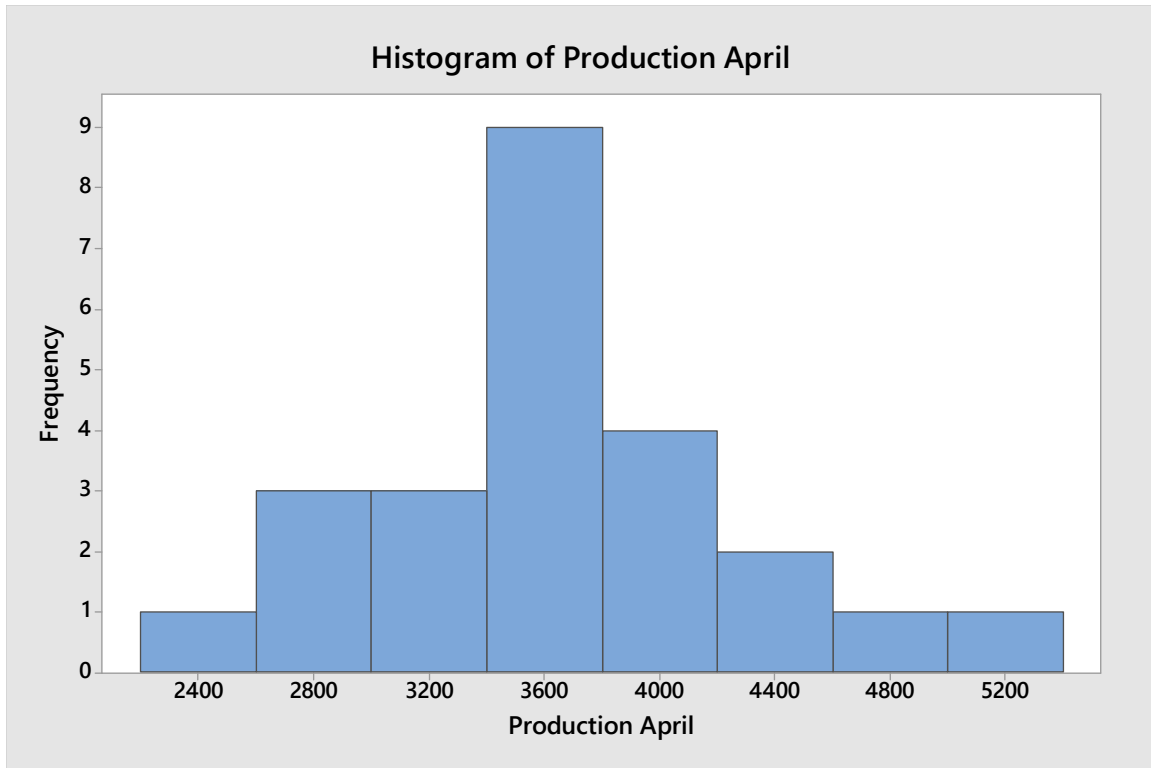
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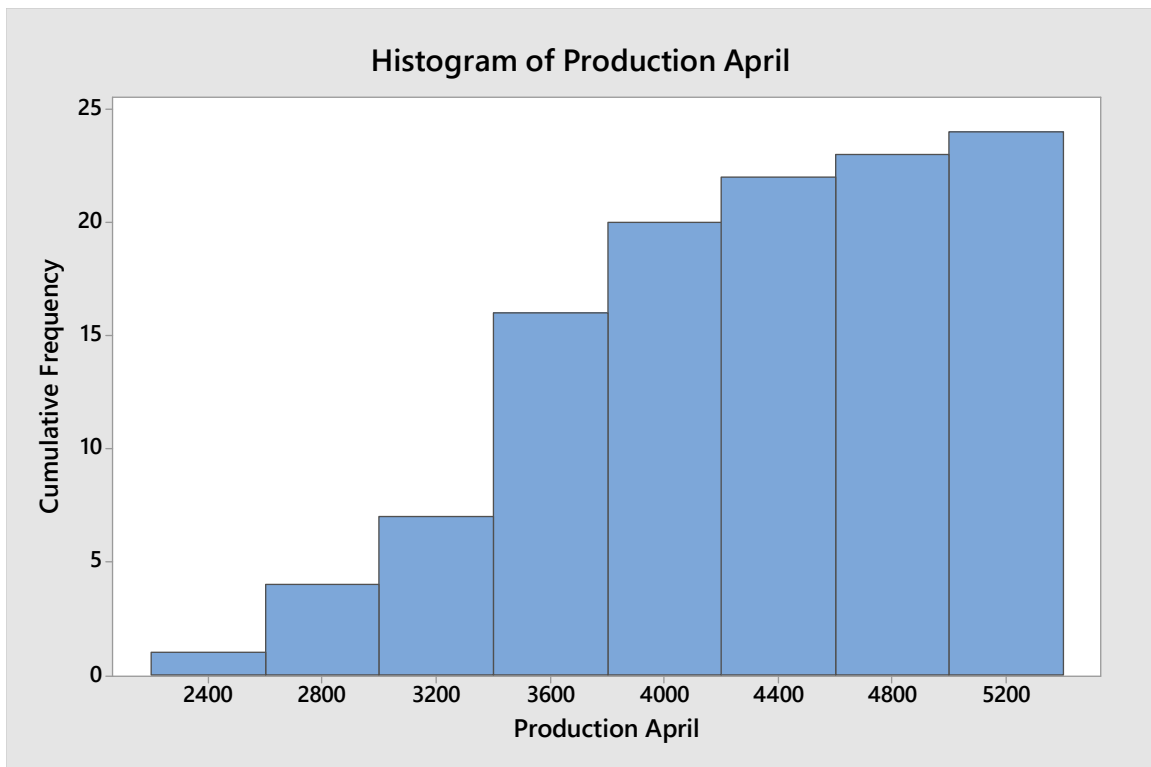
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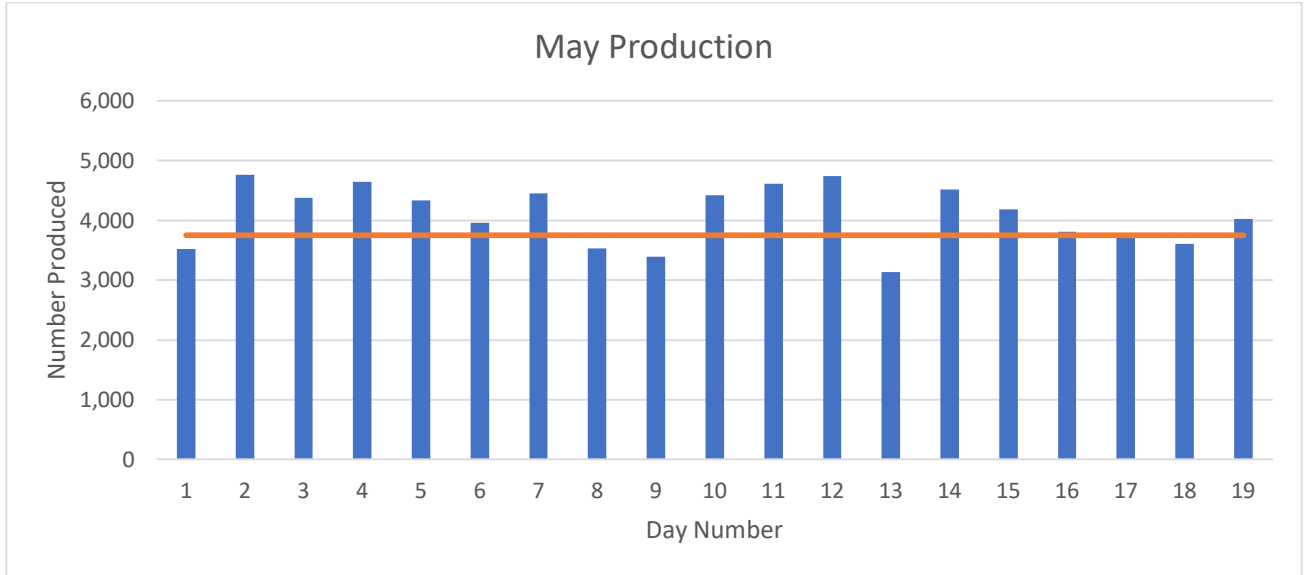
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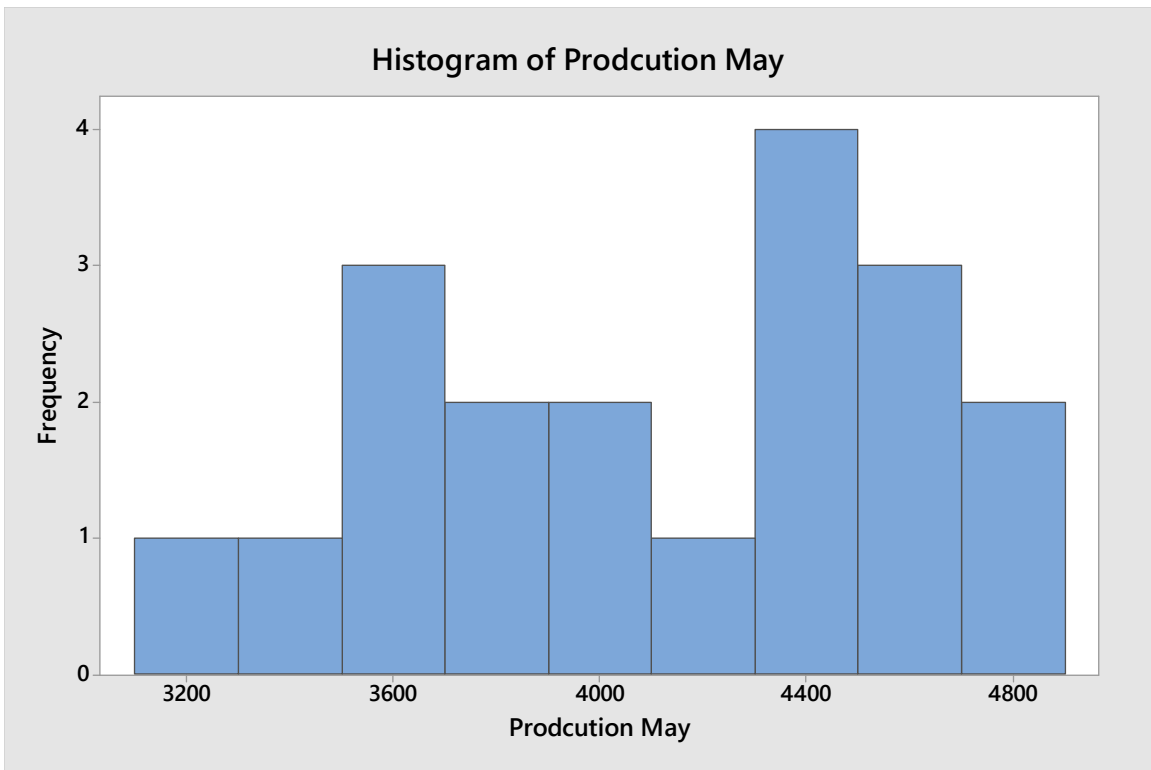
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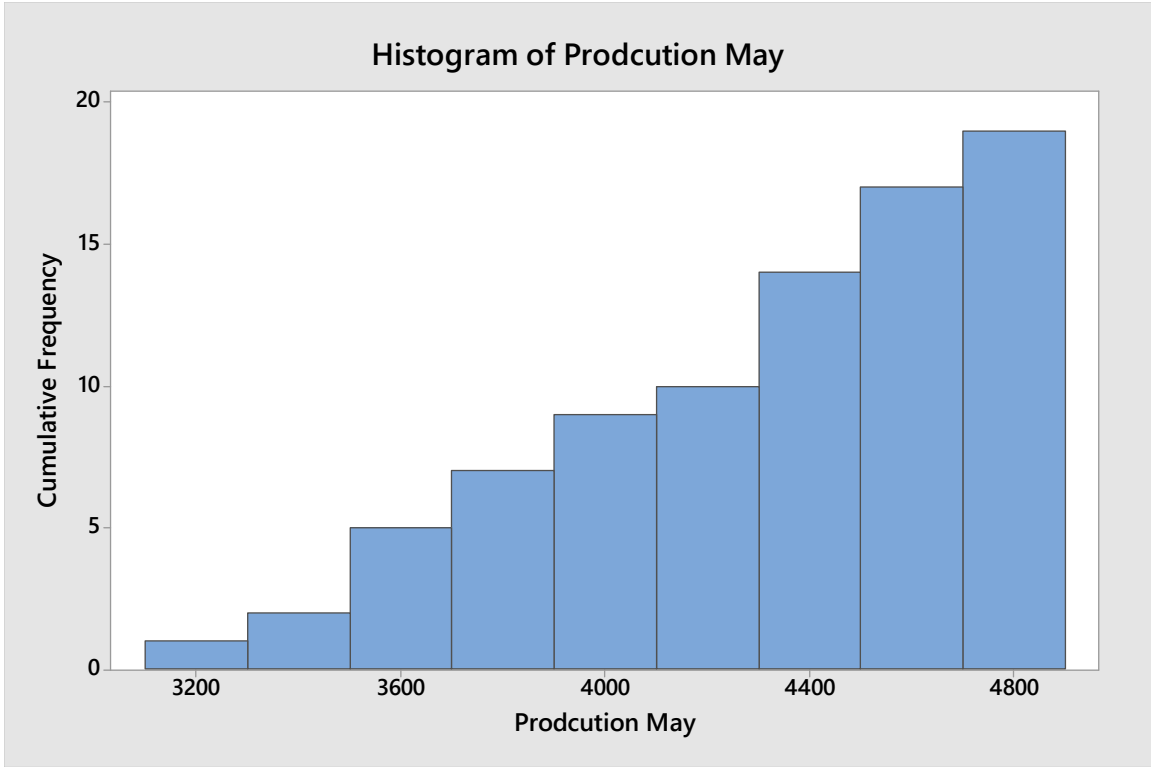
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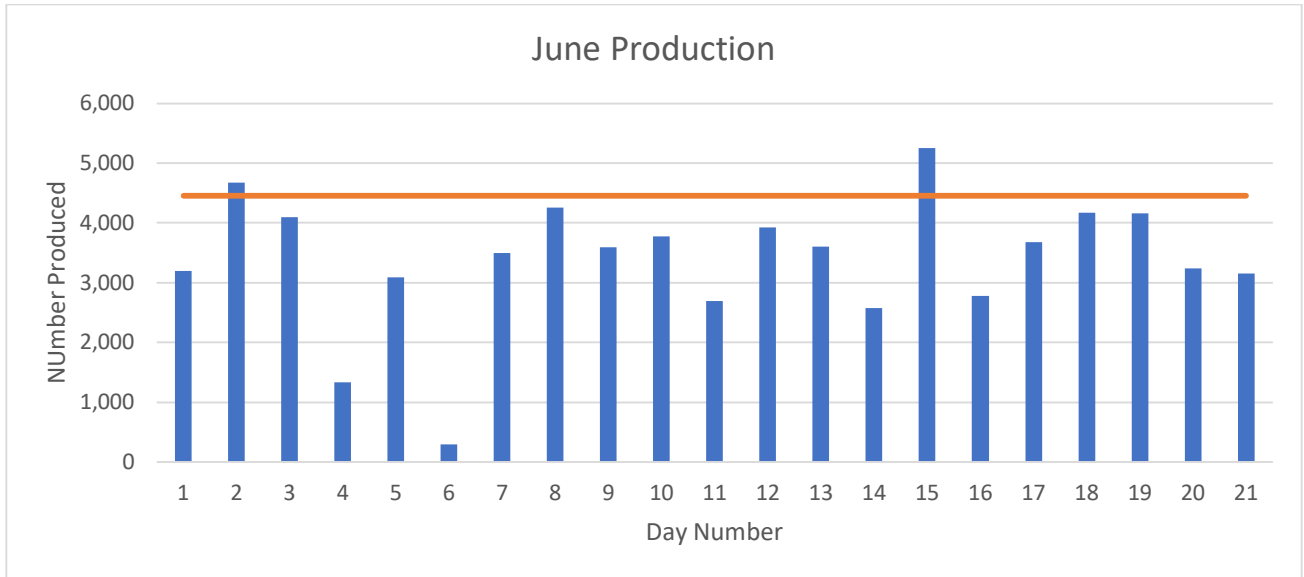
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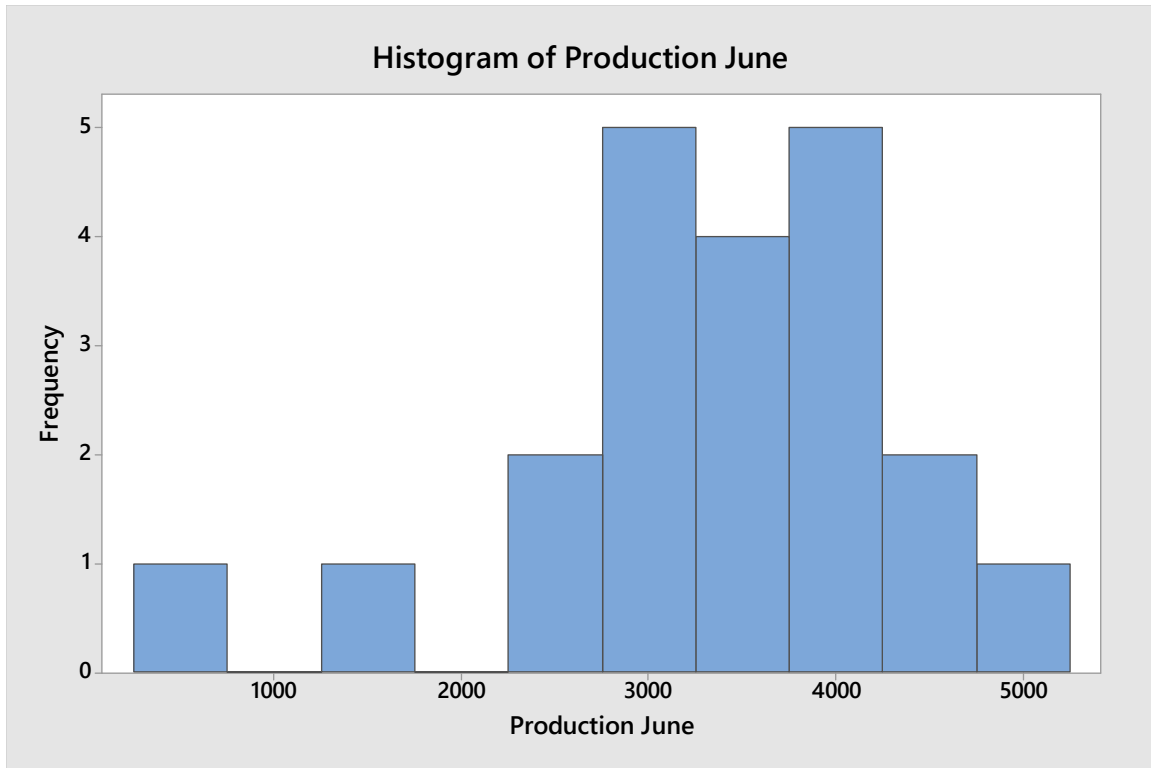
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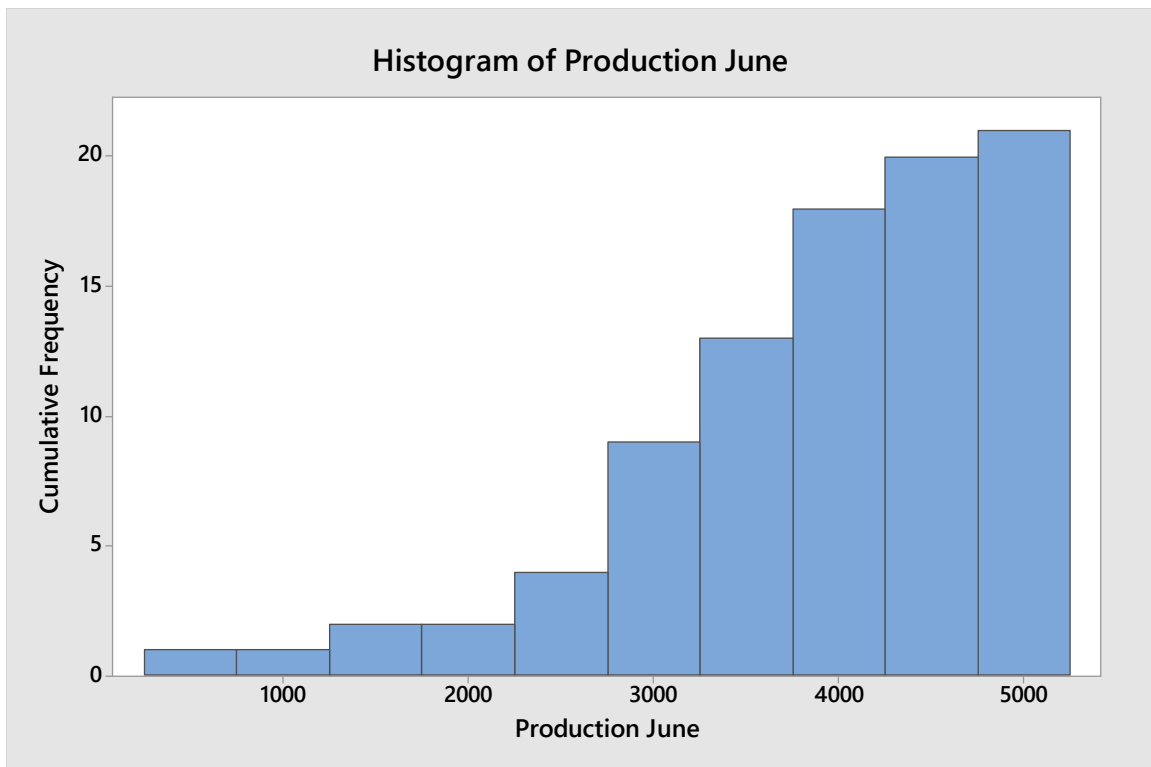
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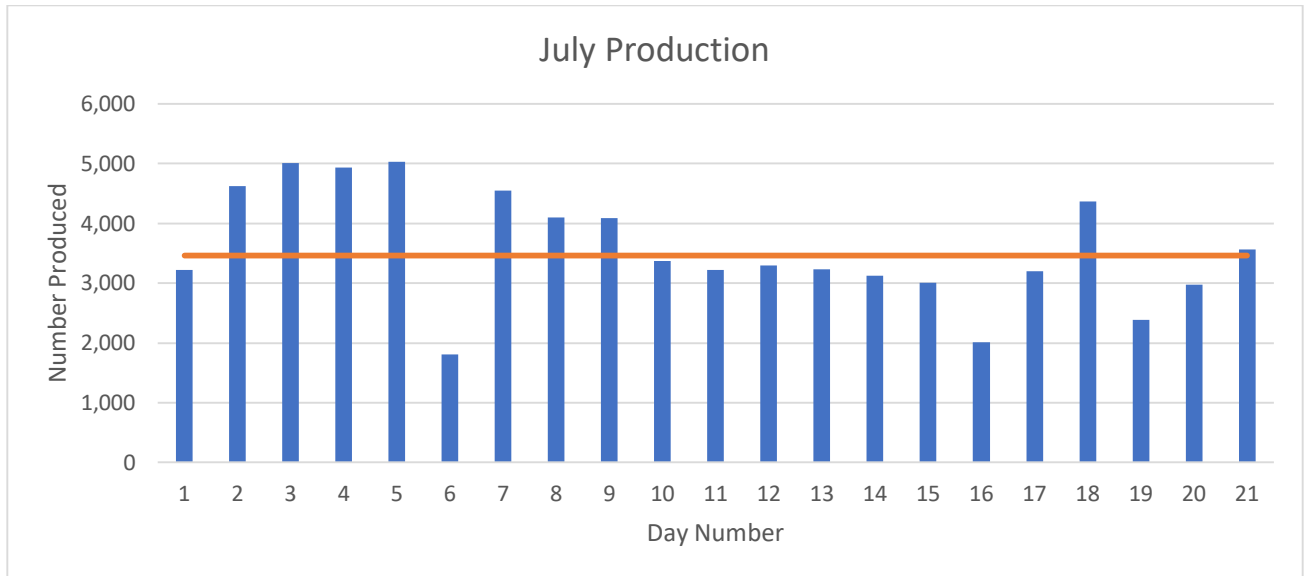
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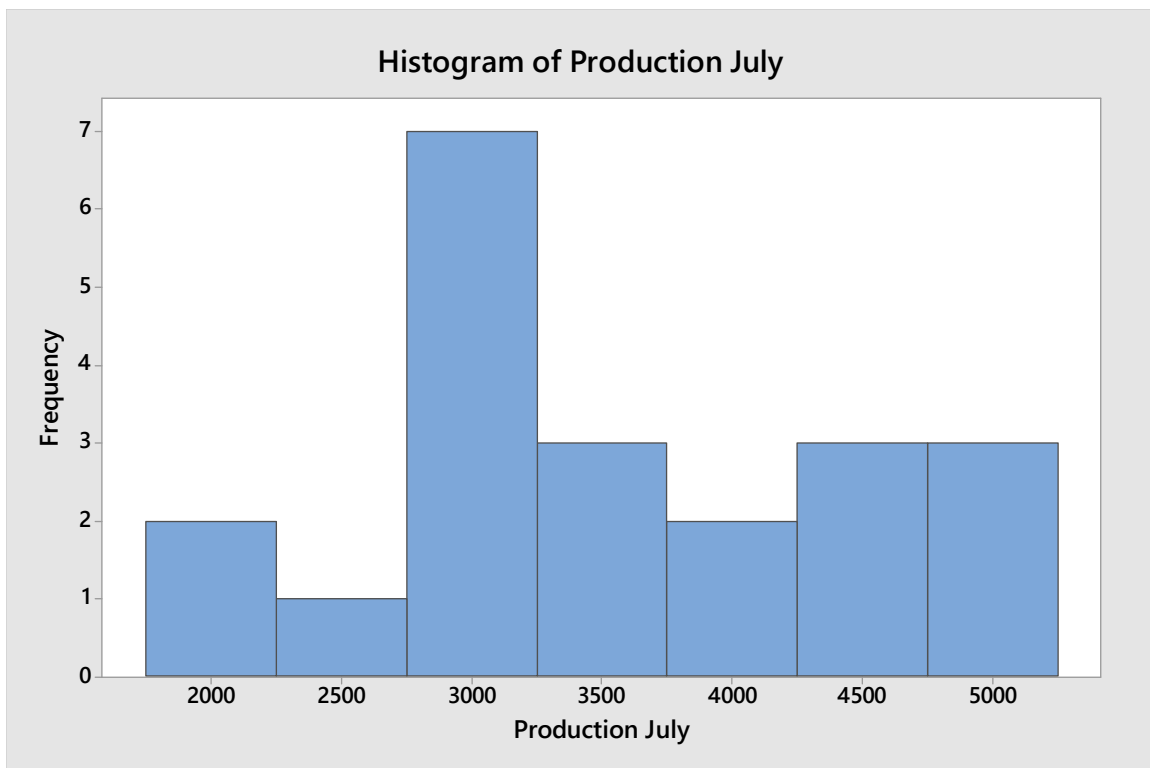
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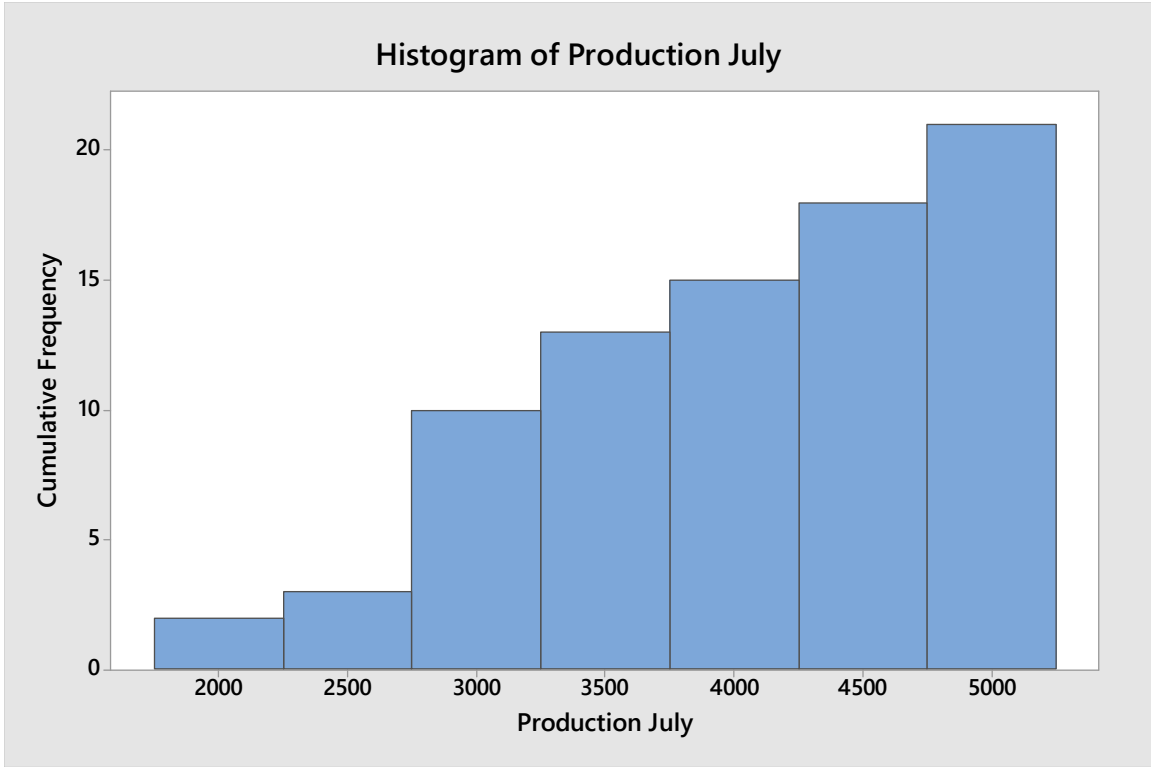
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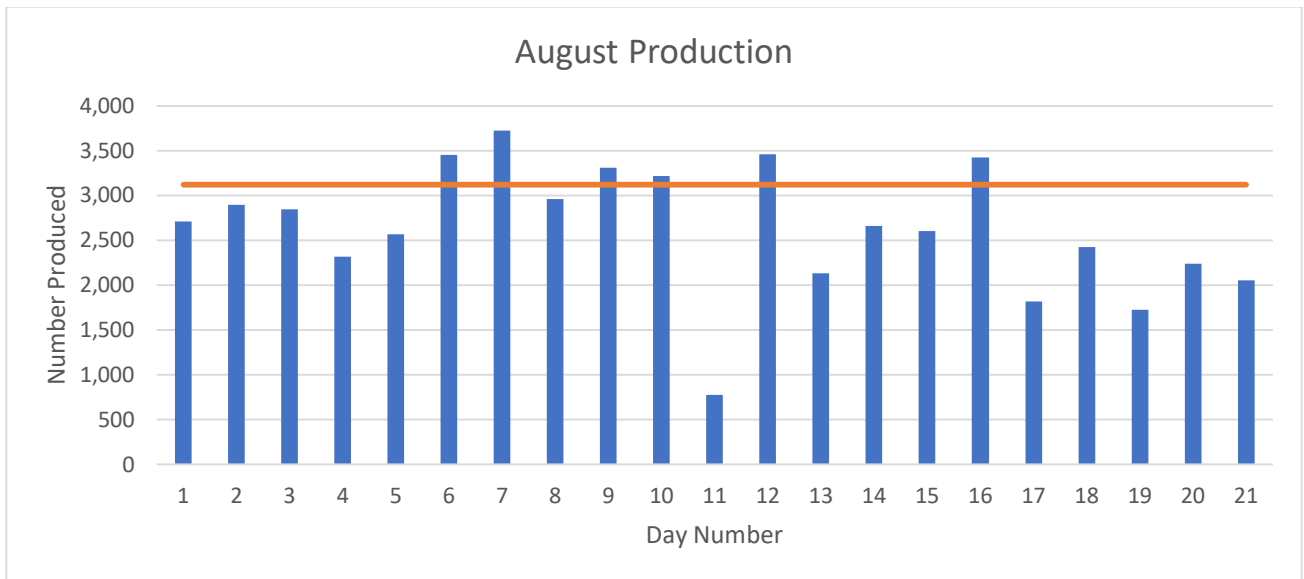
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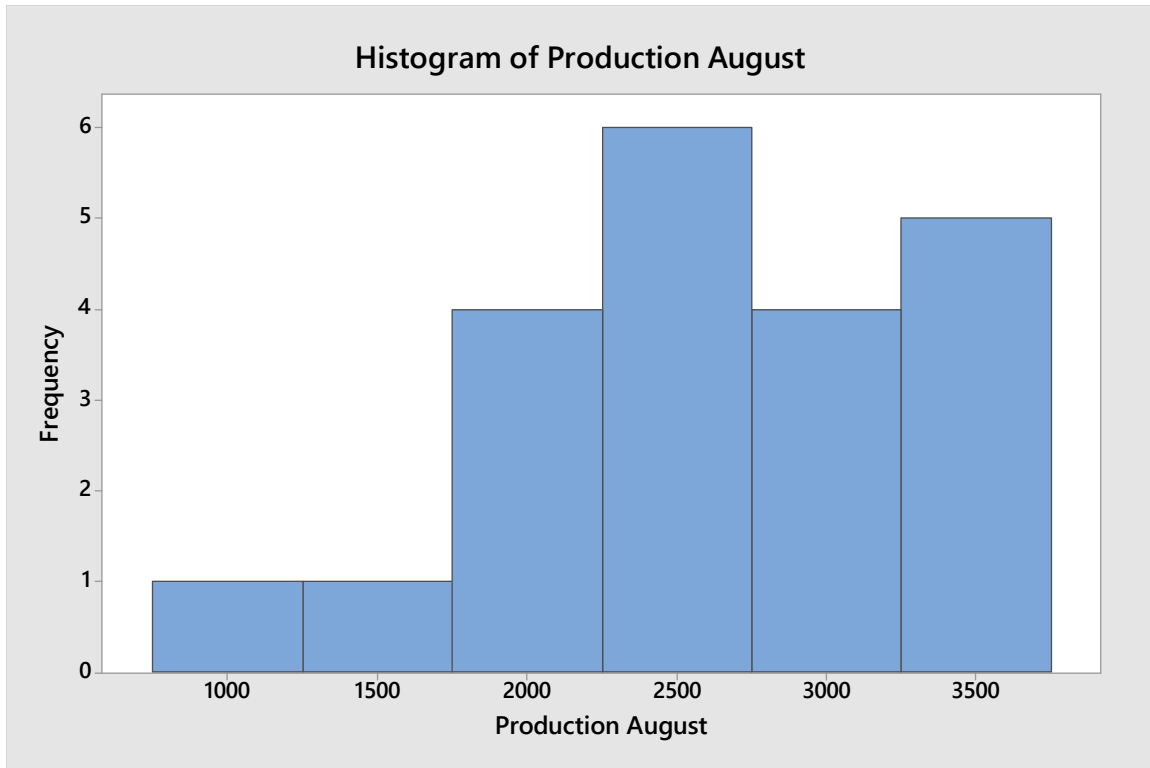
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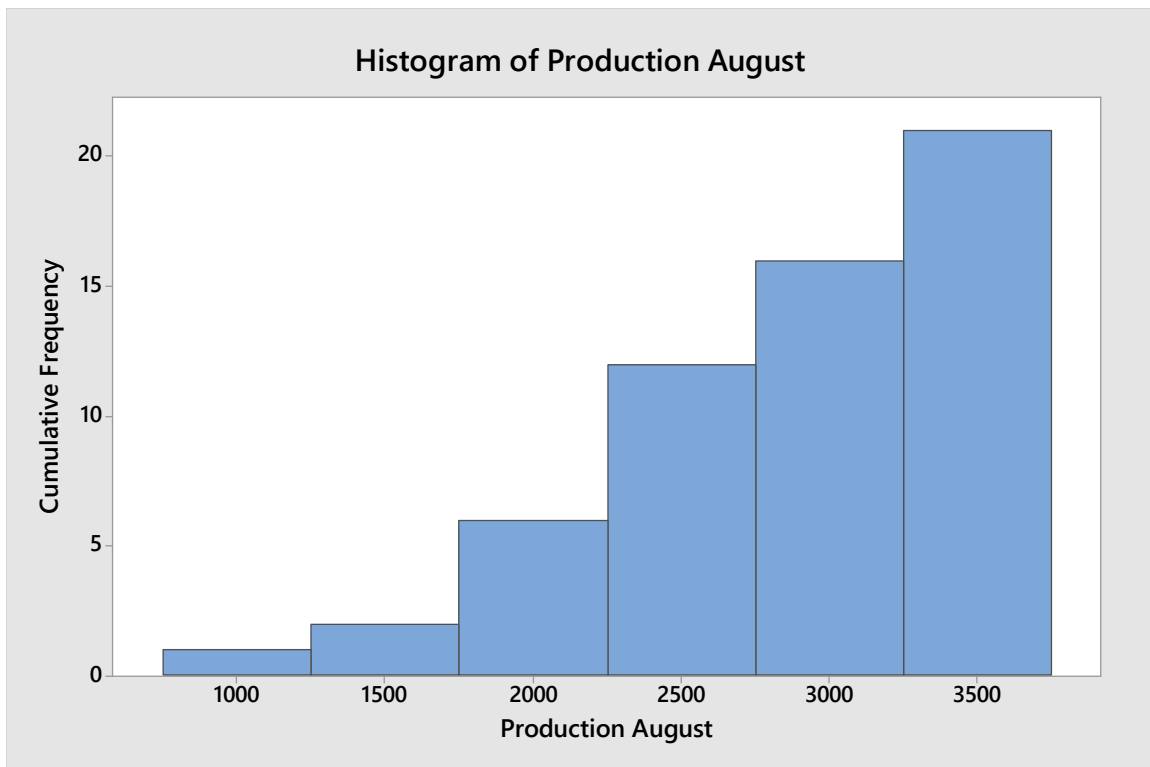
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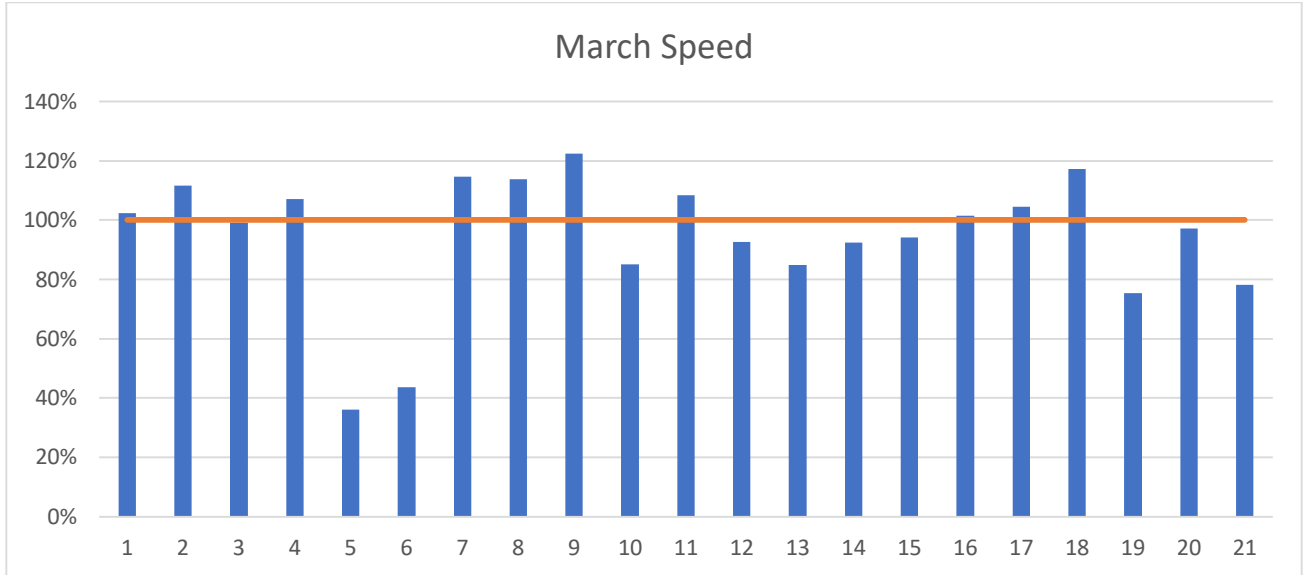
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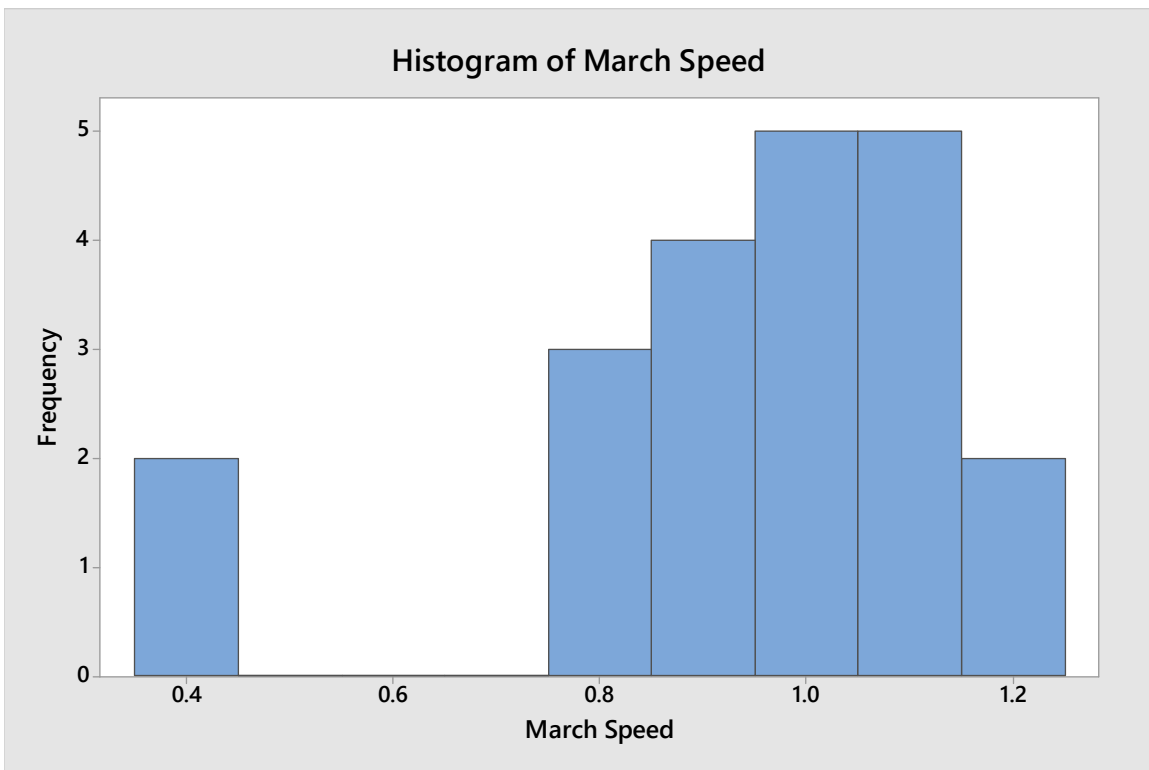
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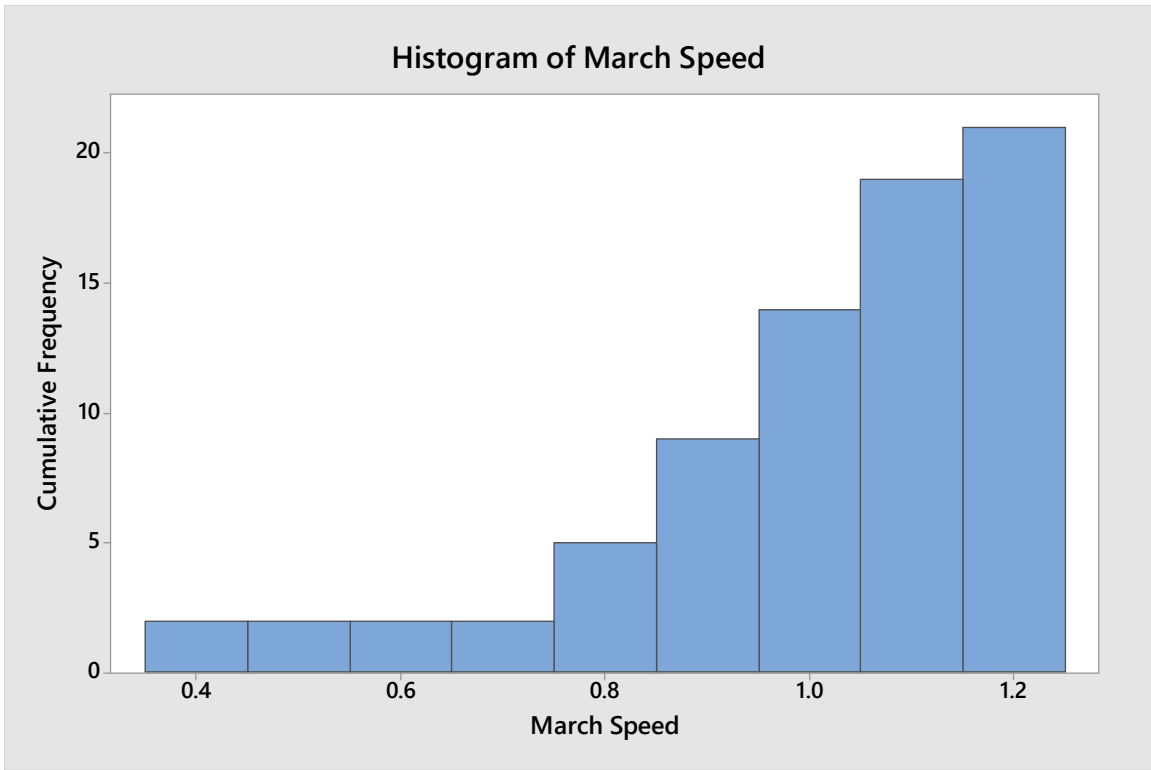
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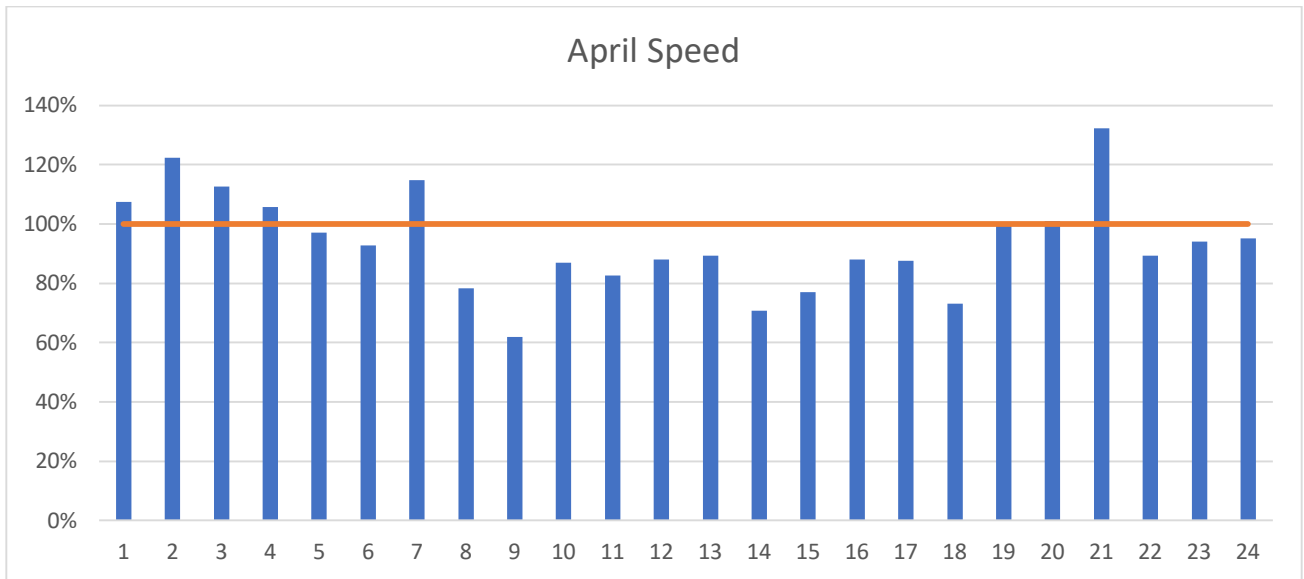
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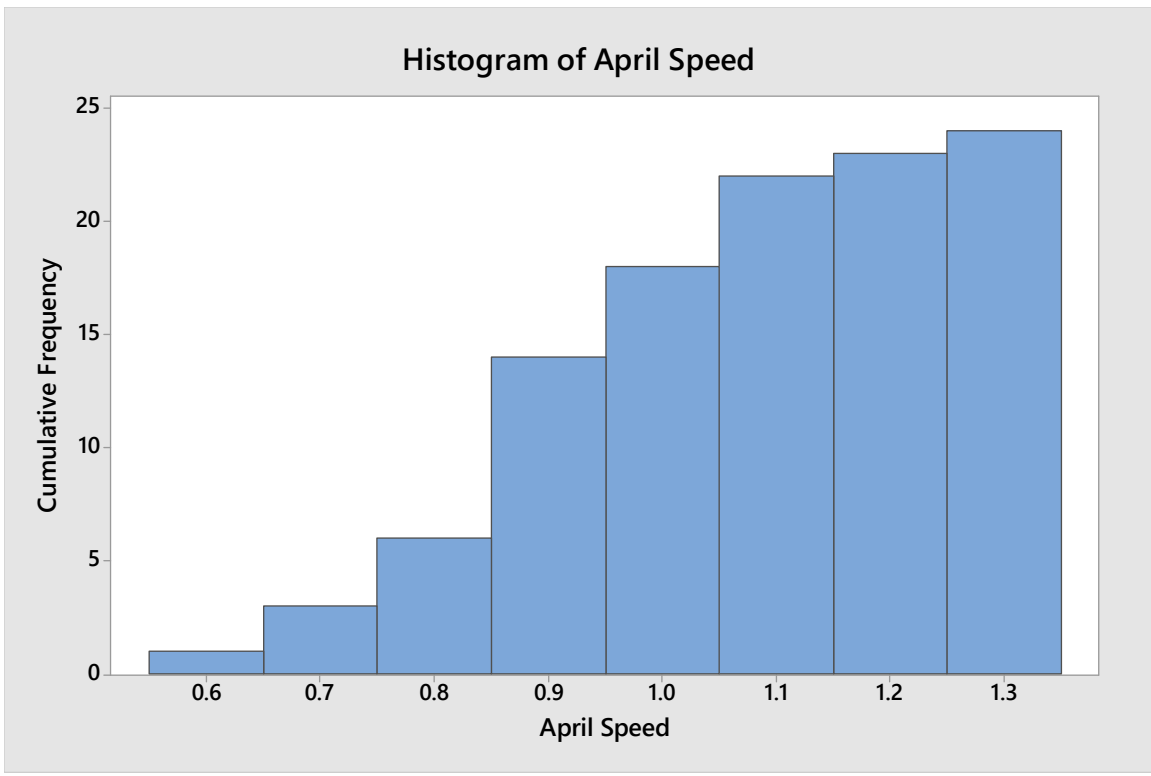
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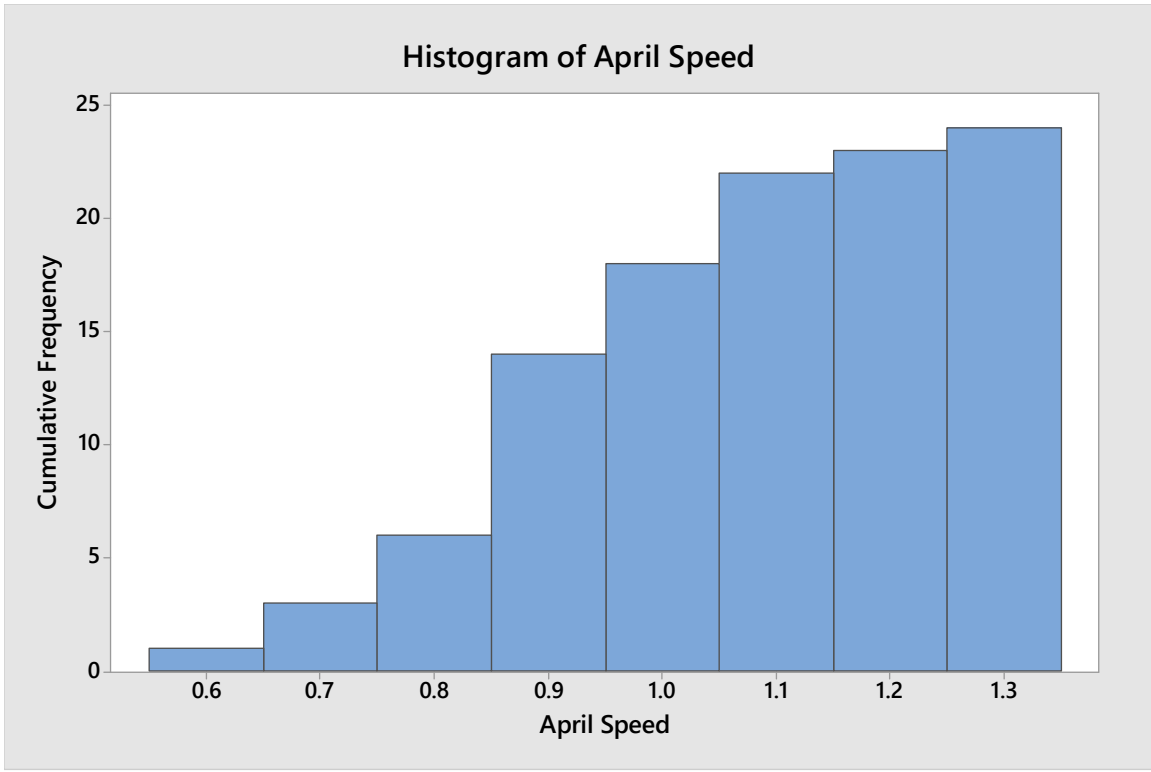
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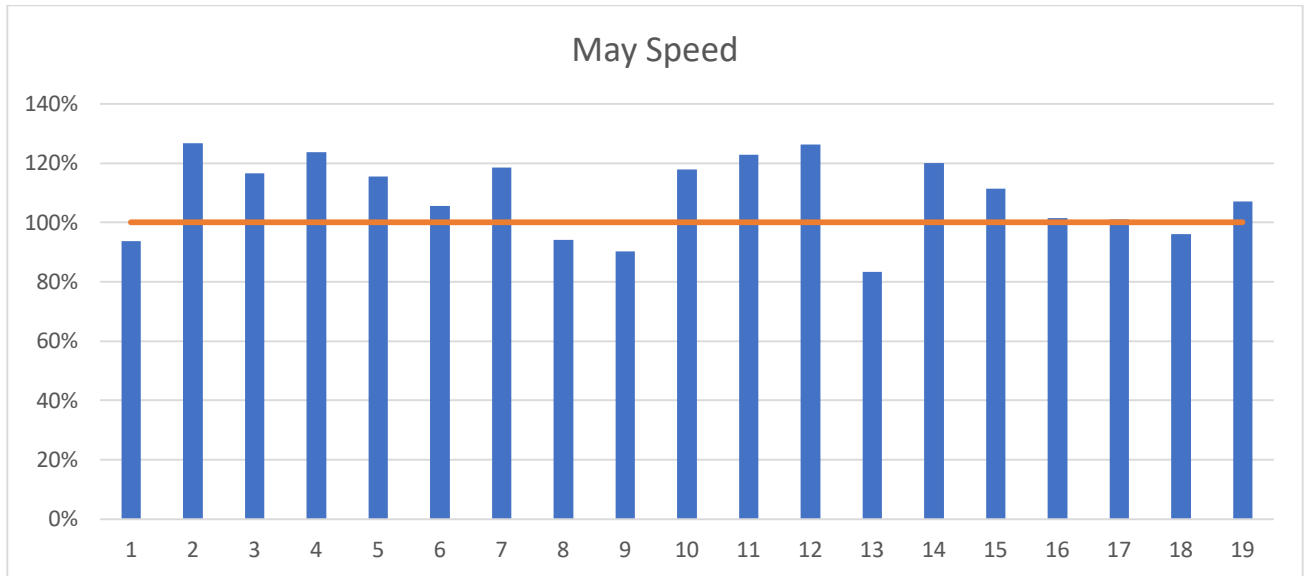
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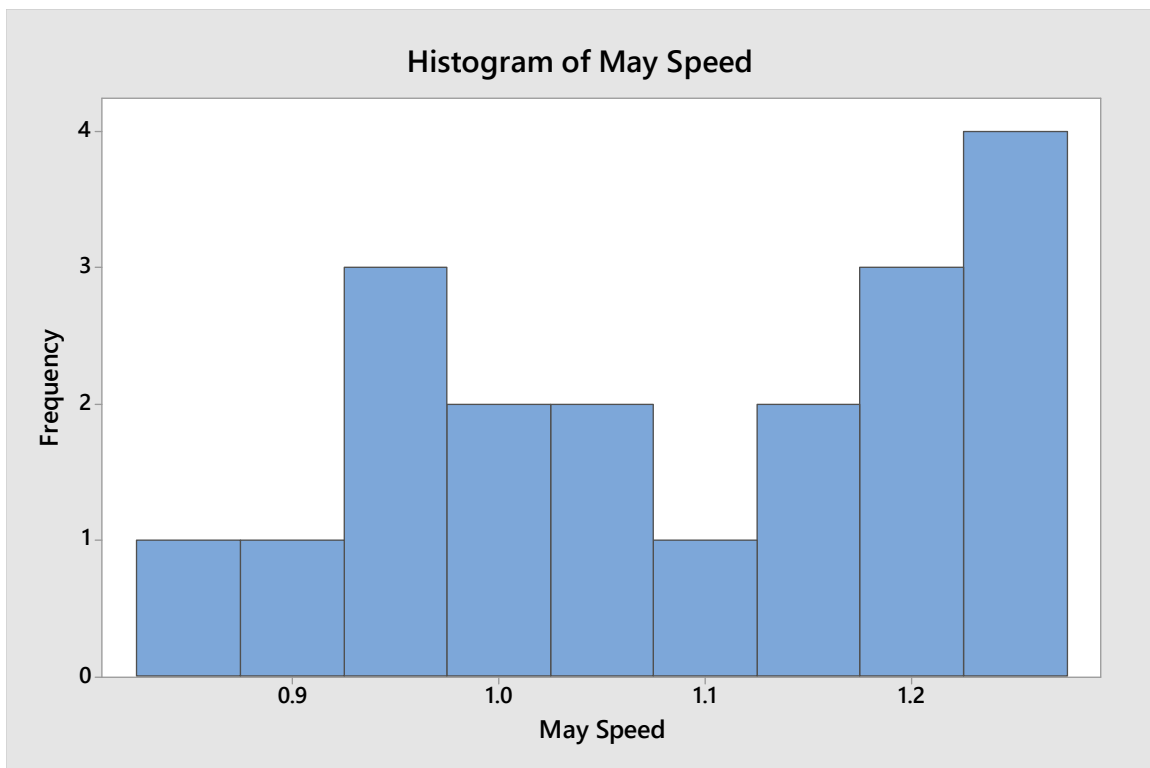
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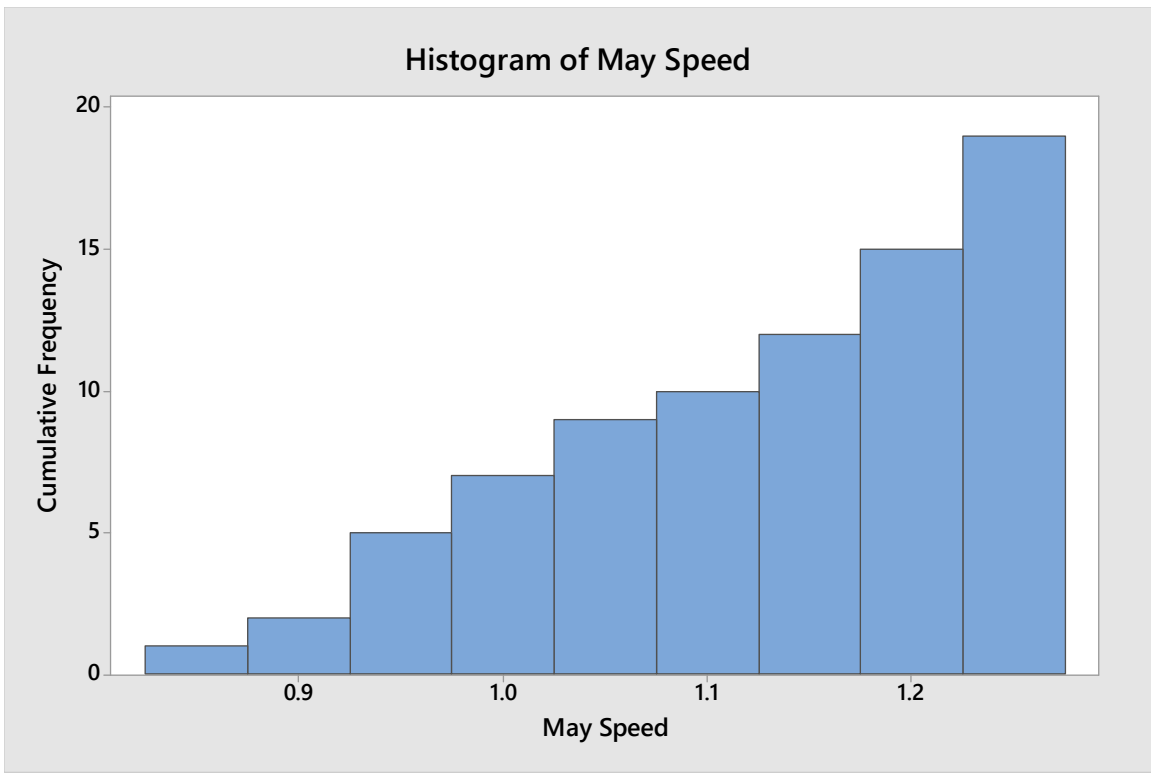
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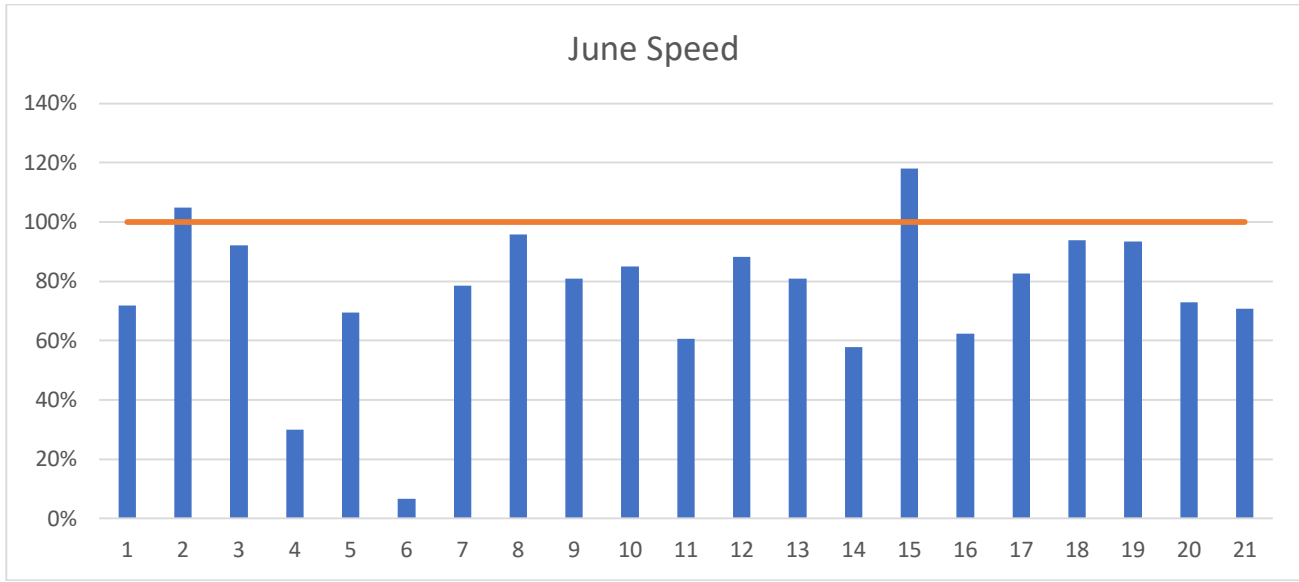
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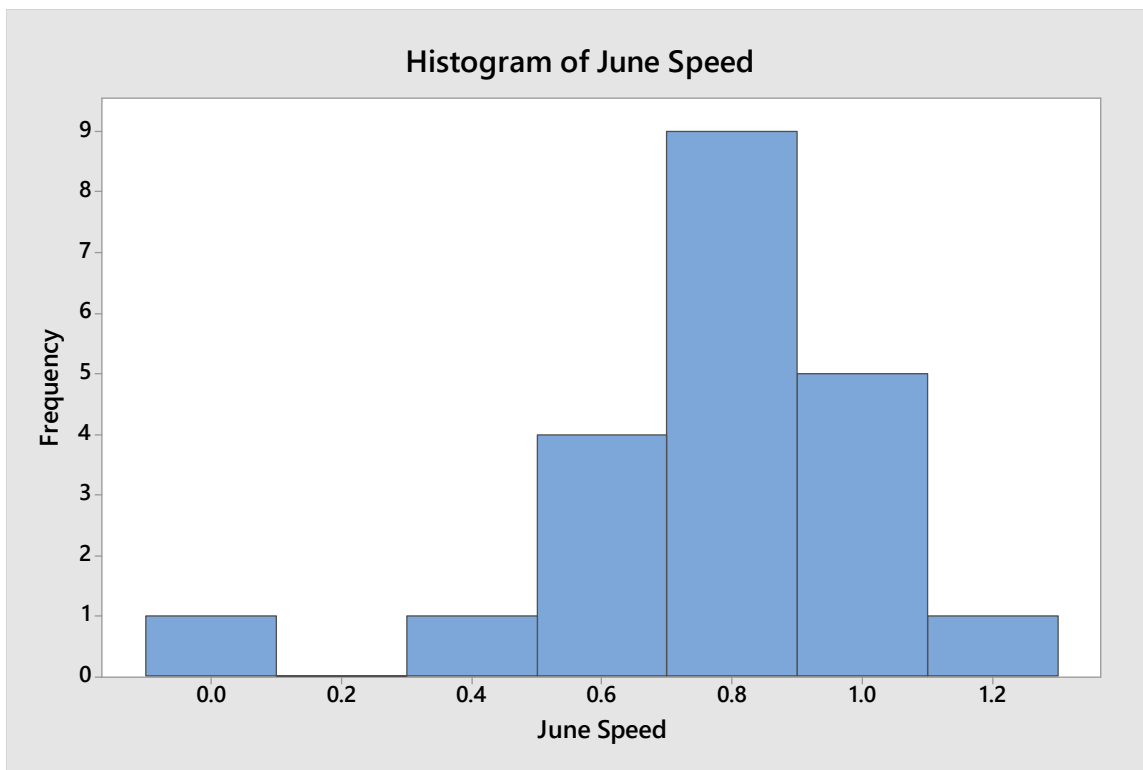
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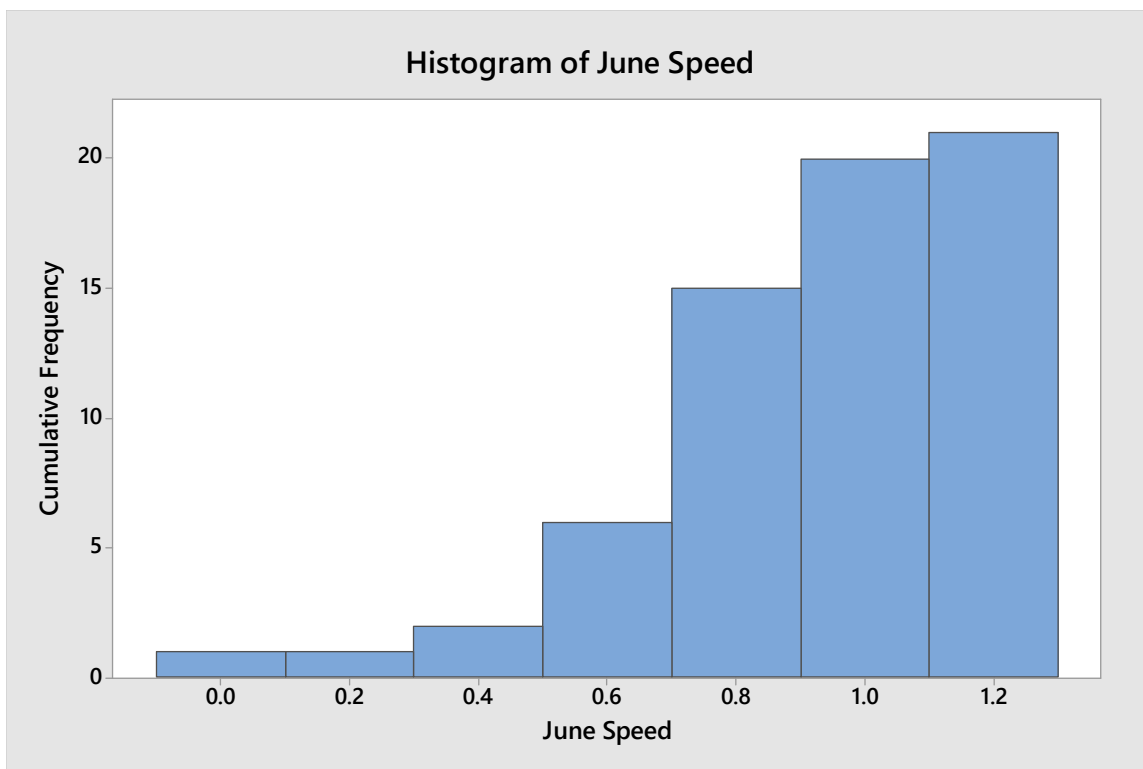
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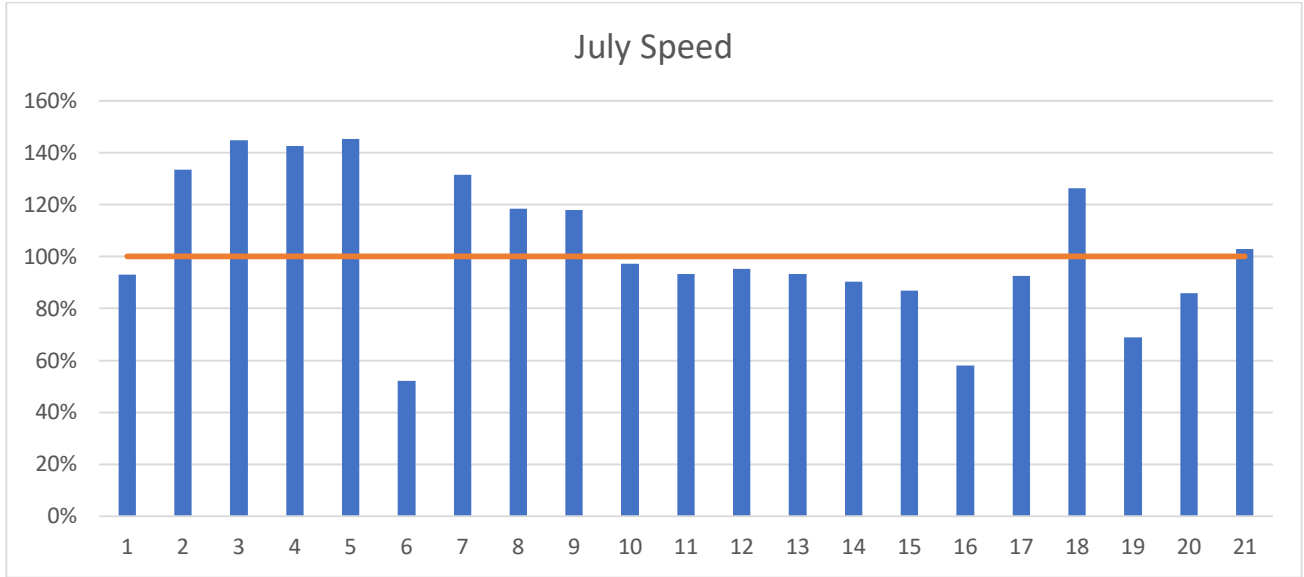
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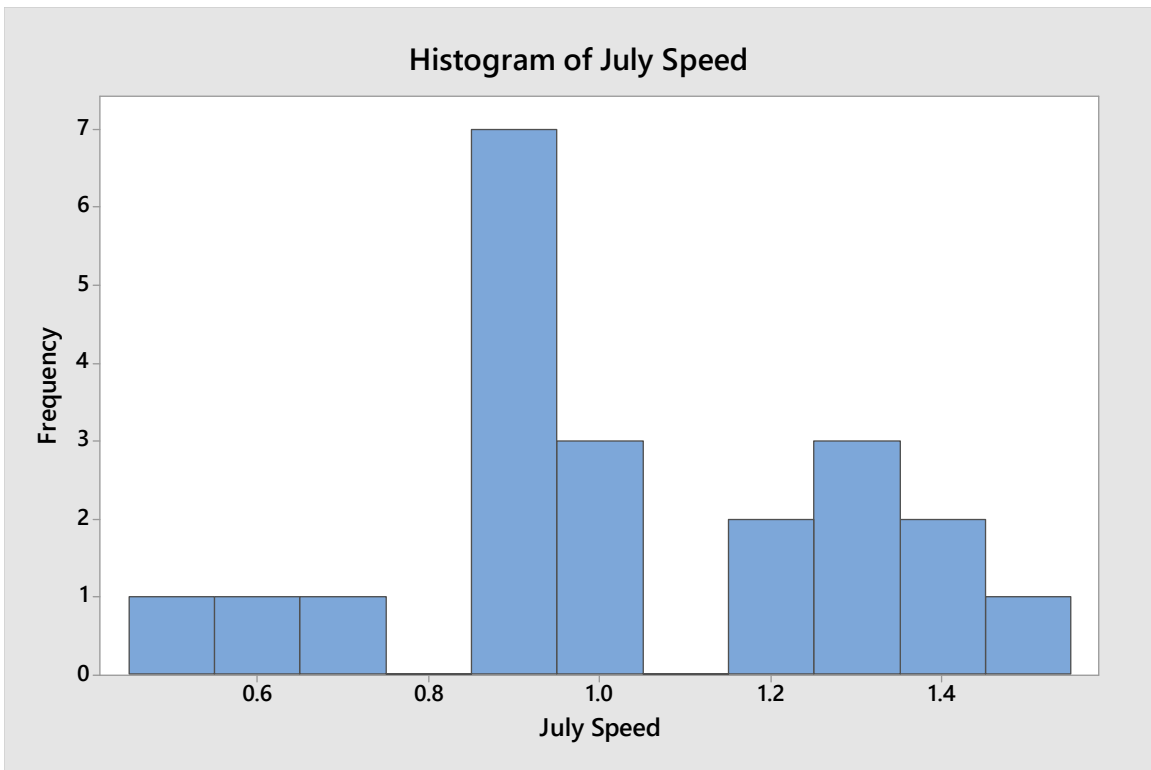
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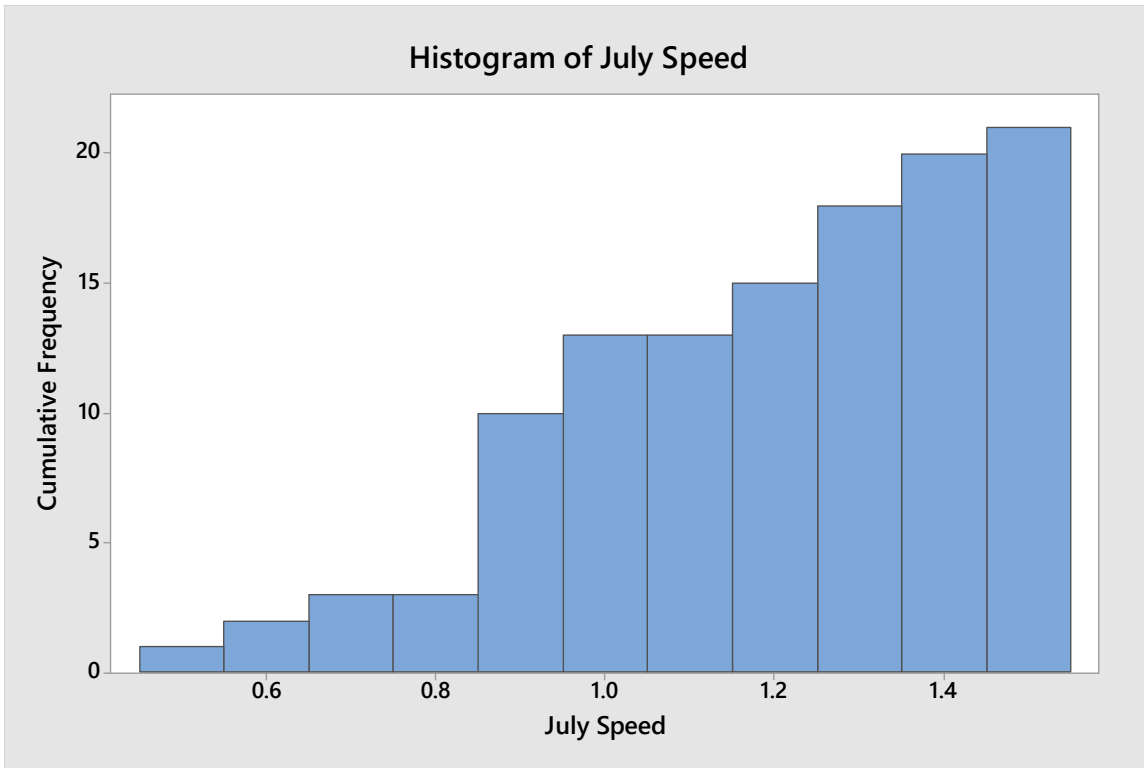
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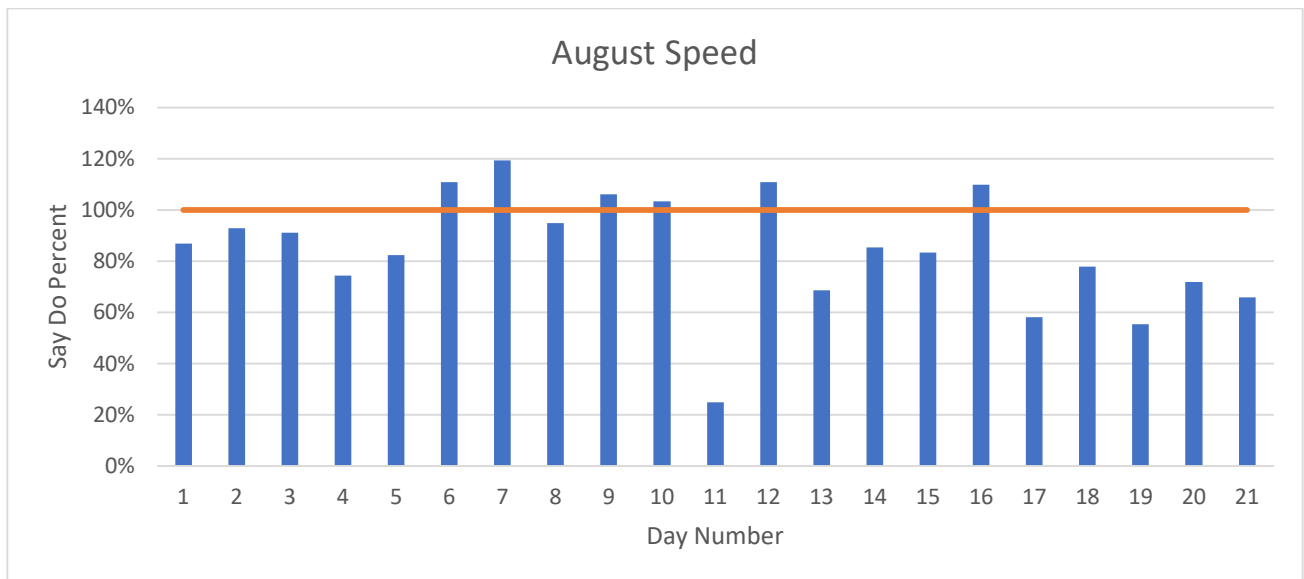
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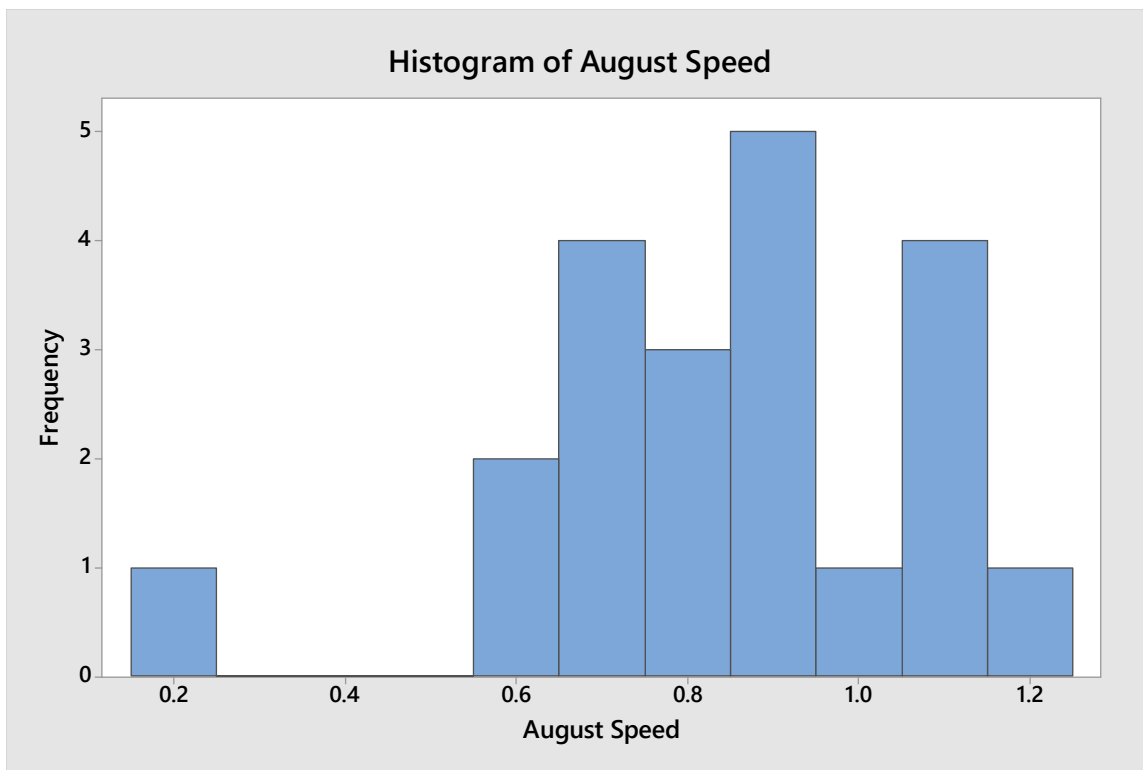
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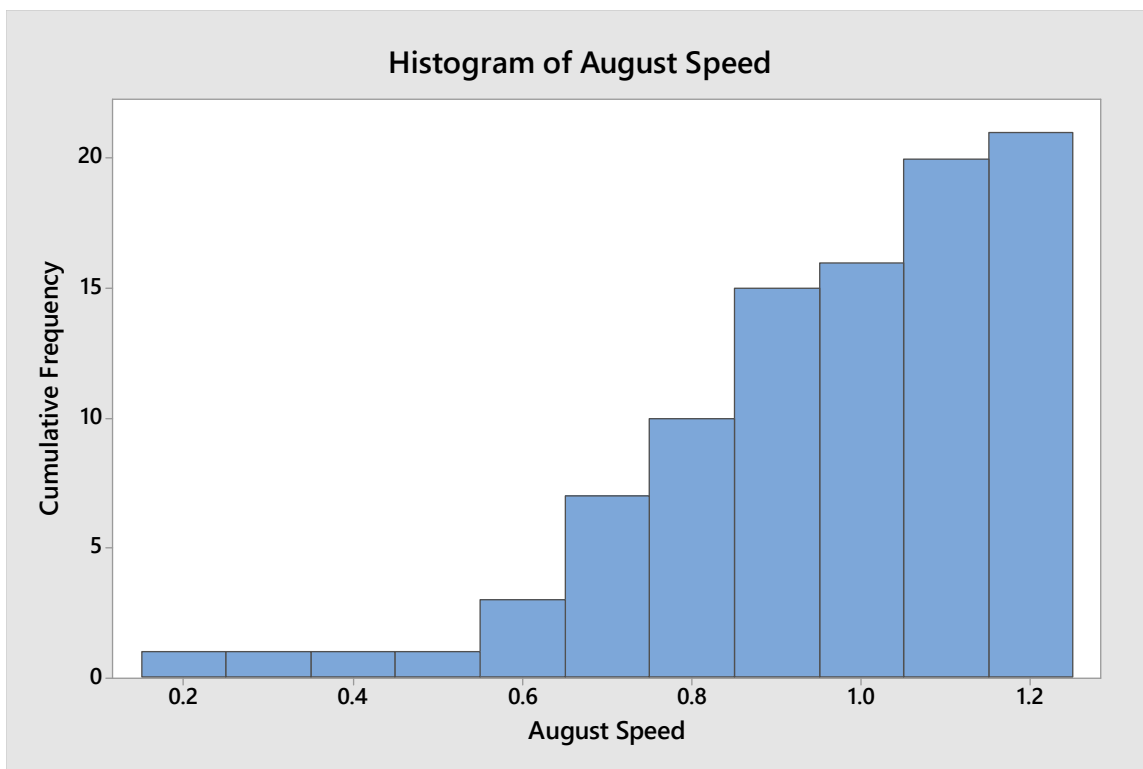
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Appendix C: Cost Analysis
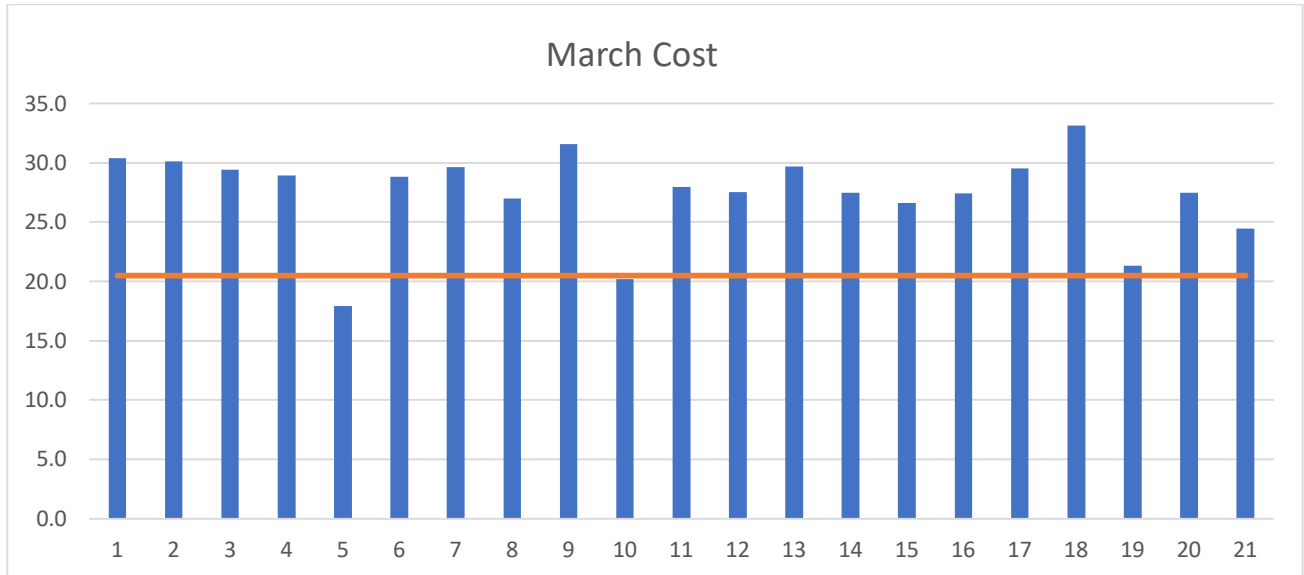
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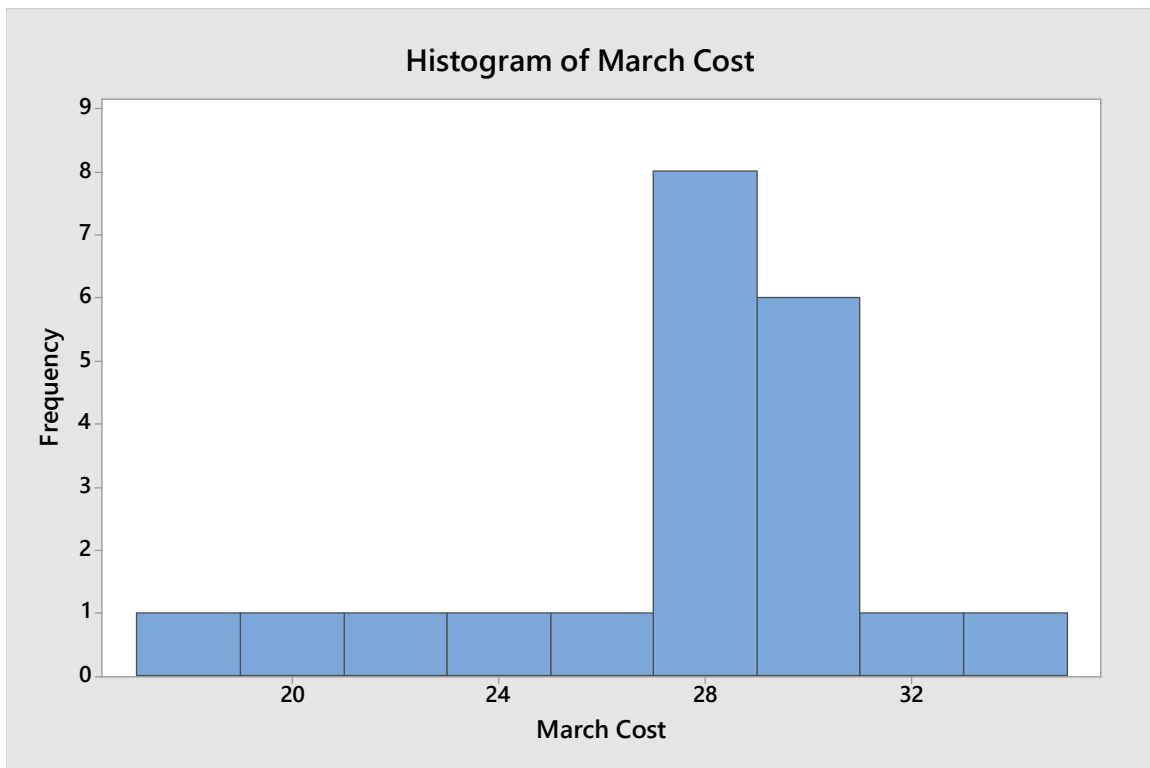
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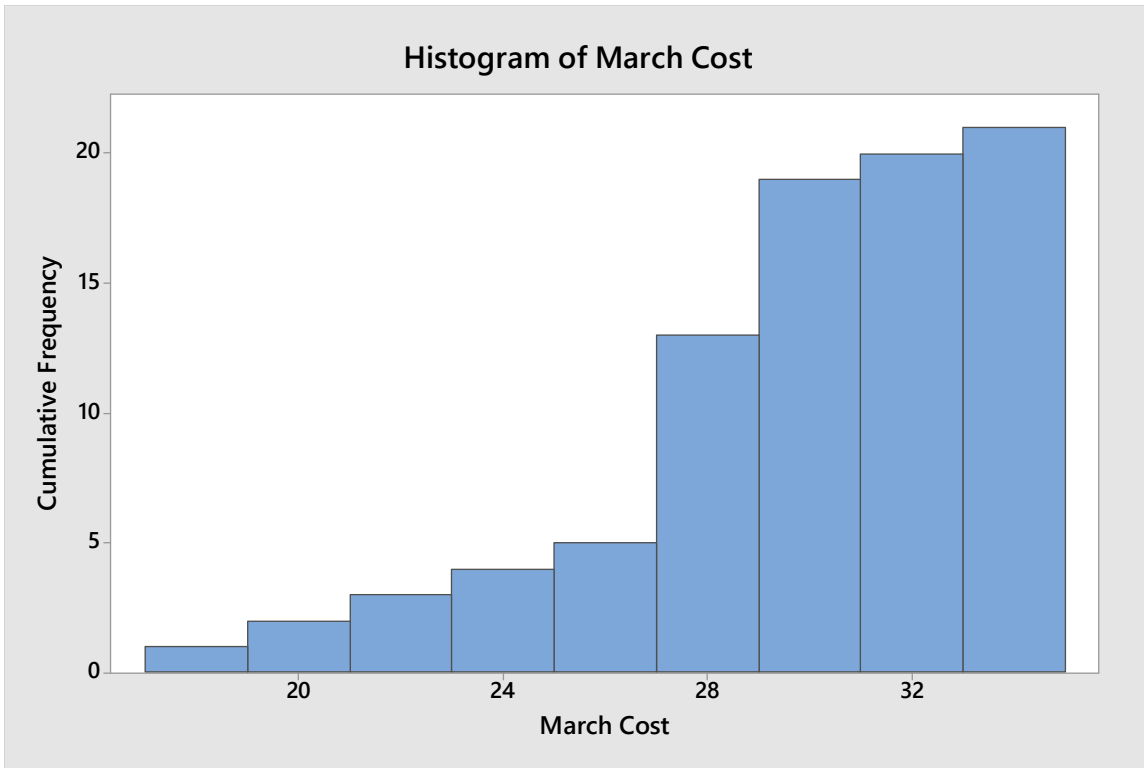
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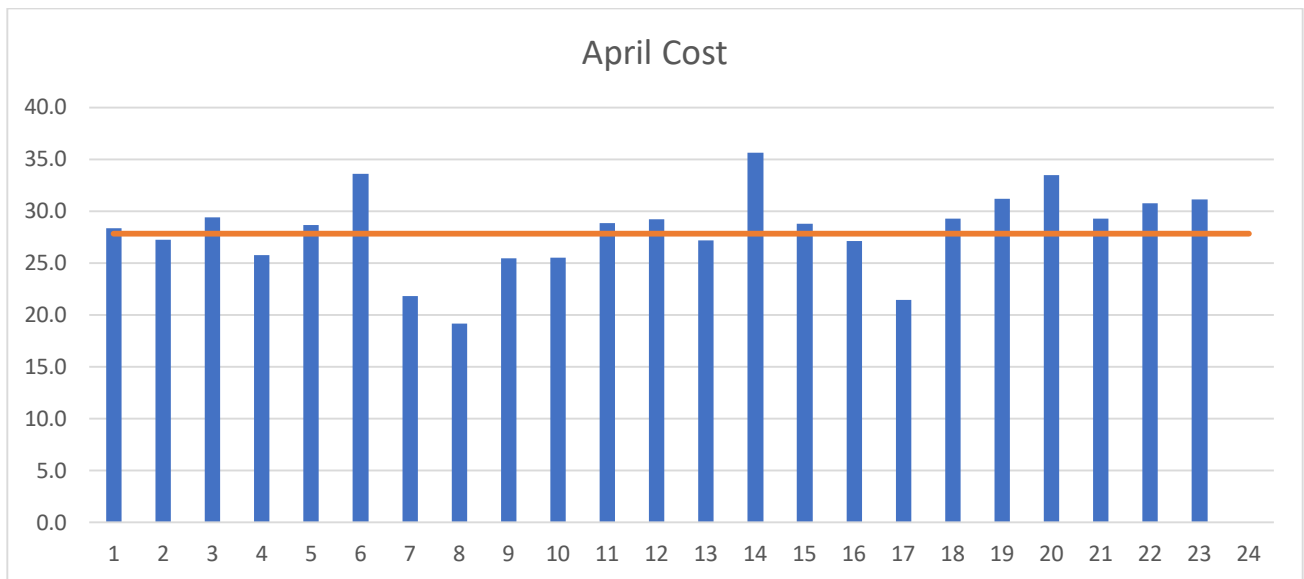
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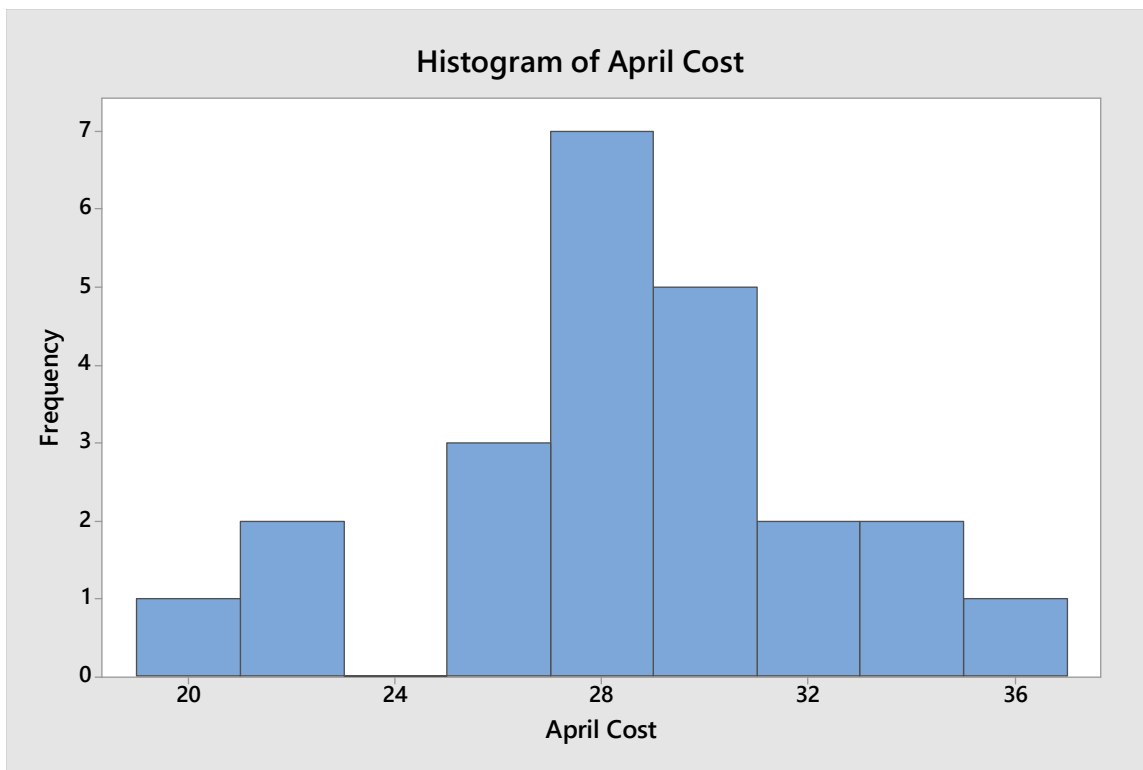
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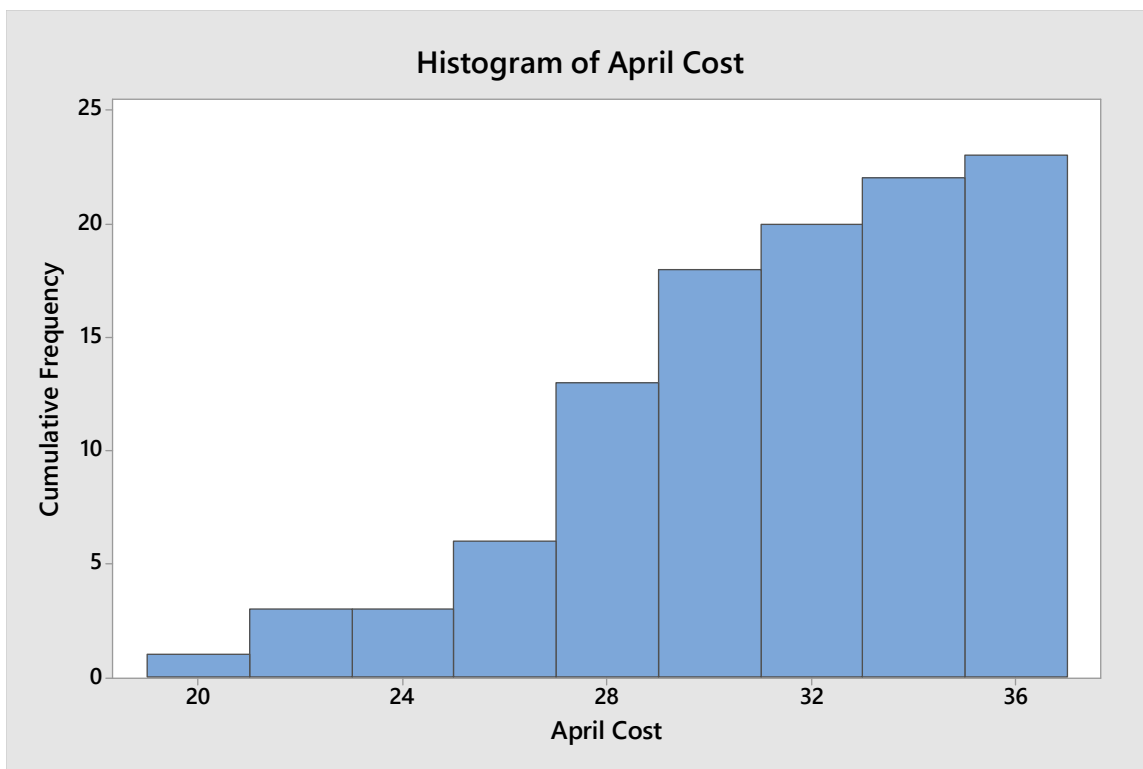
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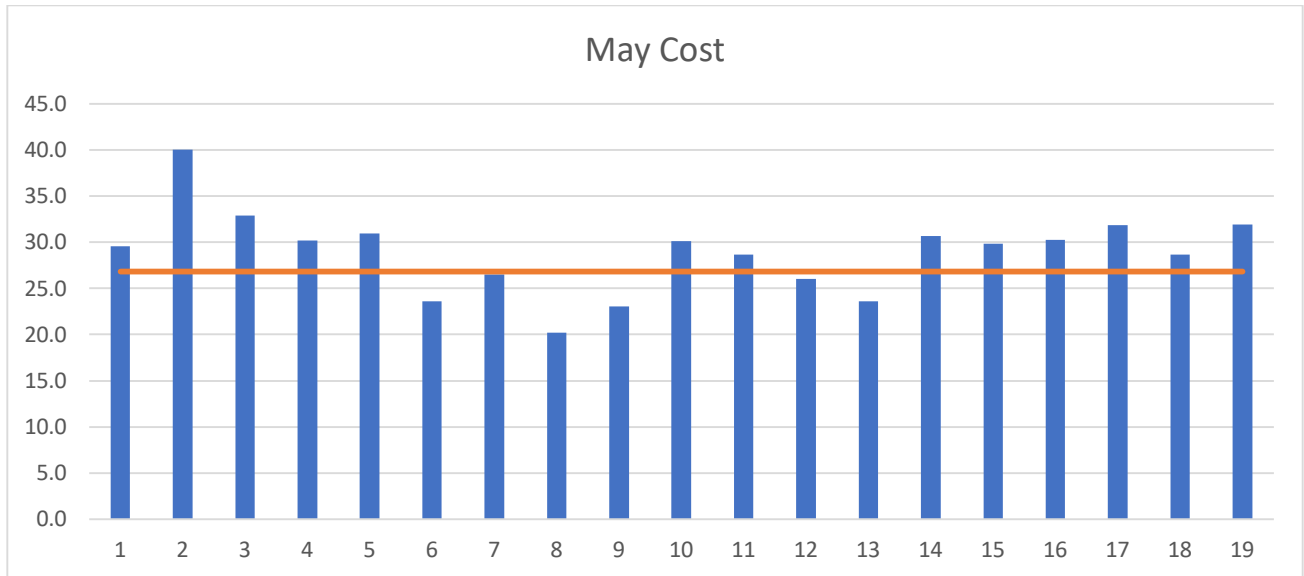
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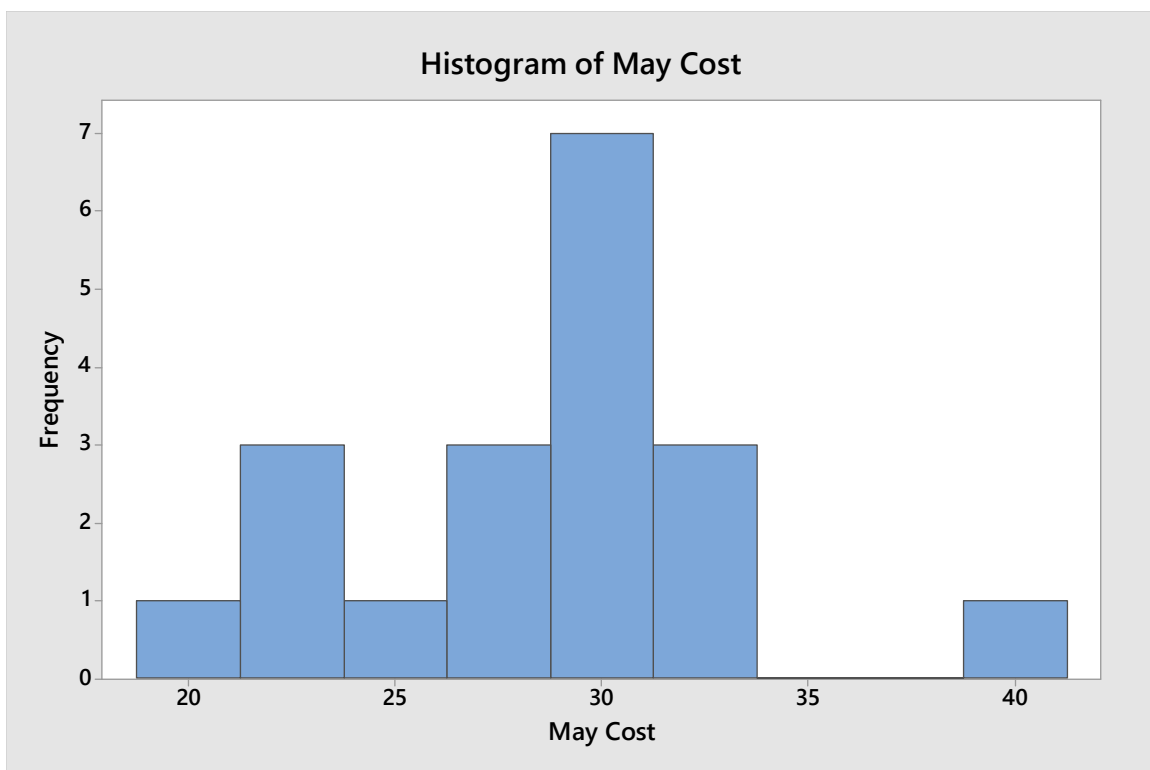
Figure C8: *May Daily Cost Histogram*
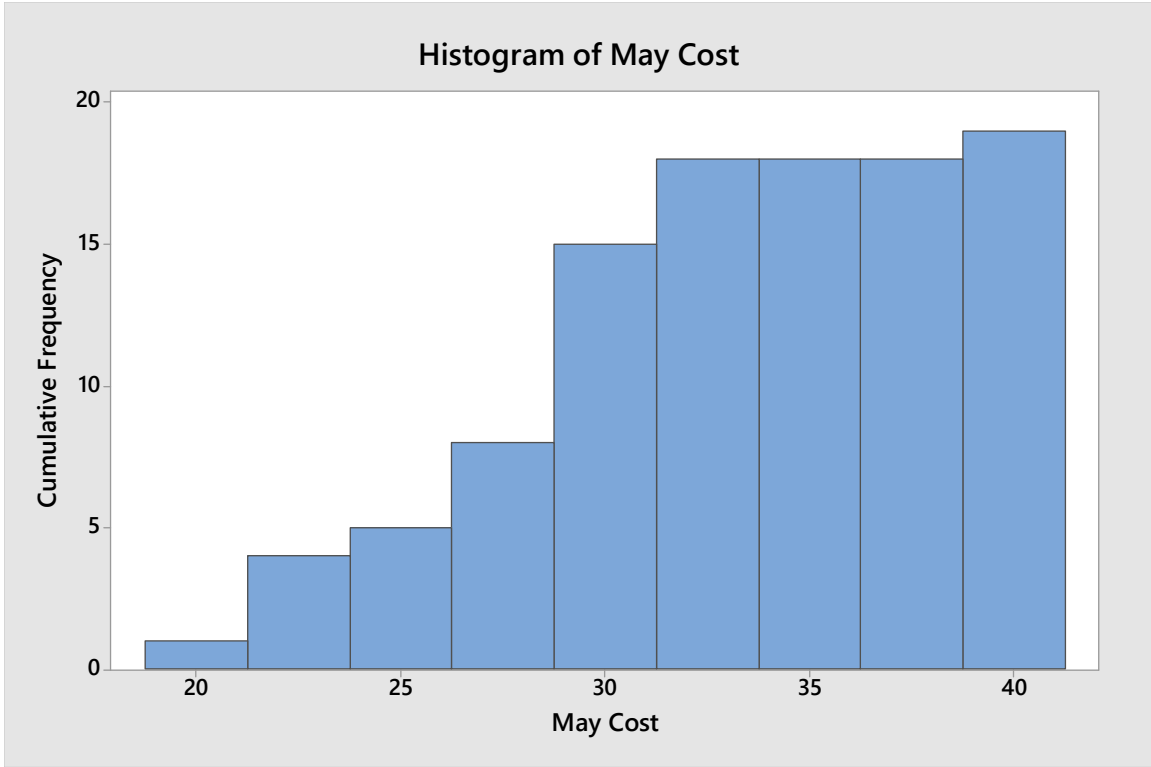
Figure C9: *May Daily Cost Cumulative Frequency Histogram*
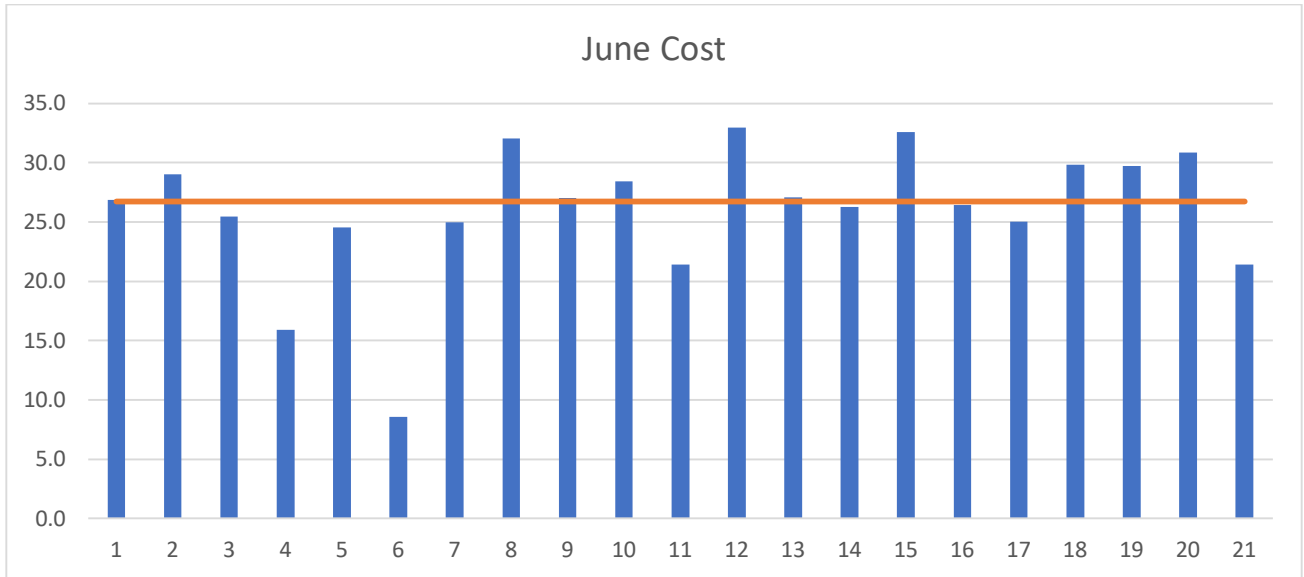
Figure C10: *June Daily Cost Data*
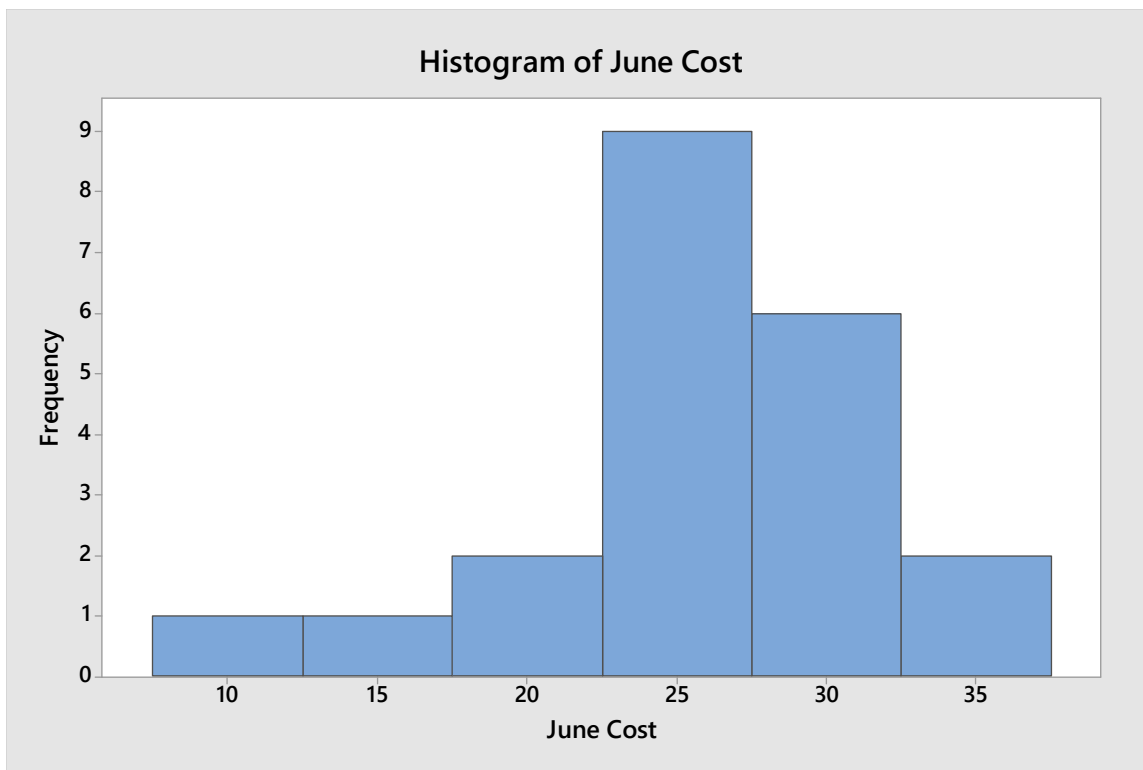
Figure C11: *June Daily Cost Histogram*
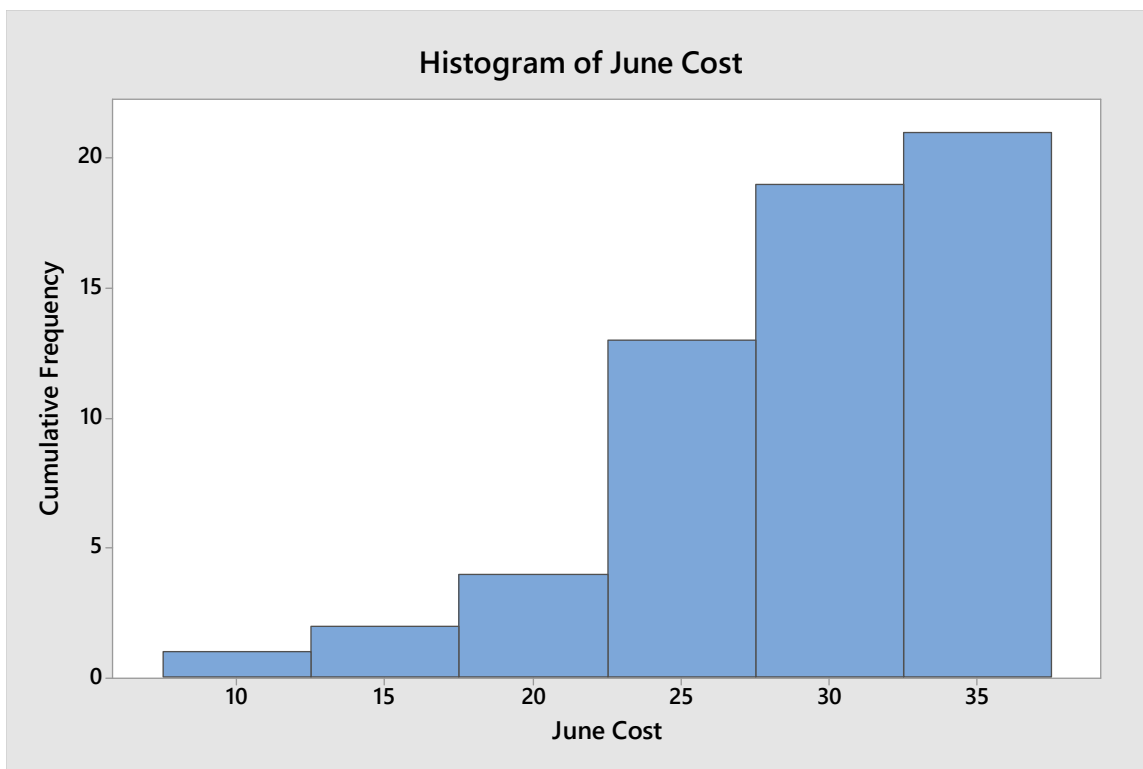
Figure C12: *June Daily Cost Cumulative Frequency Histogram*
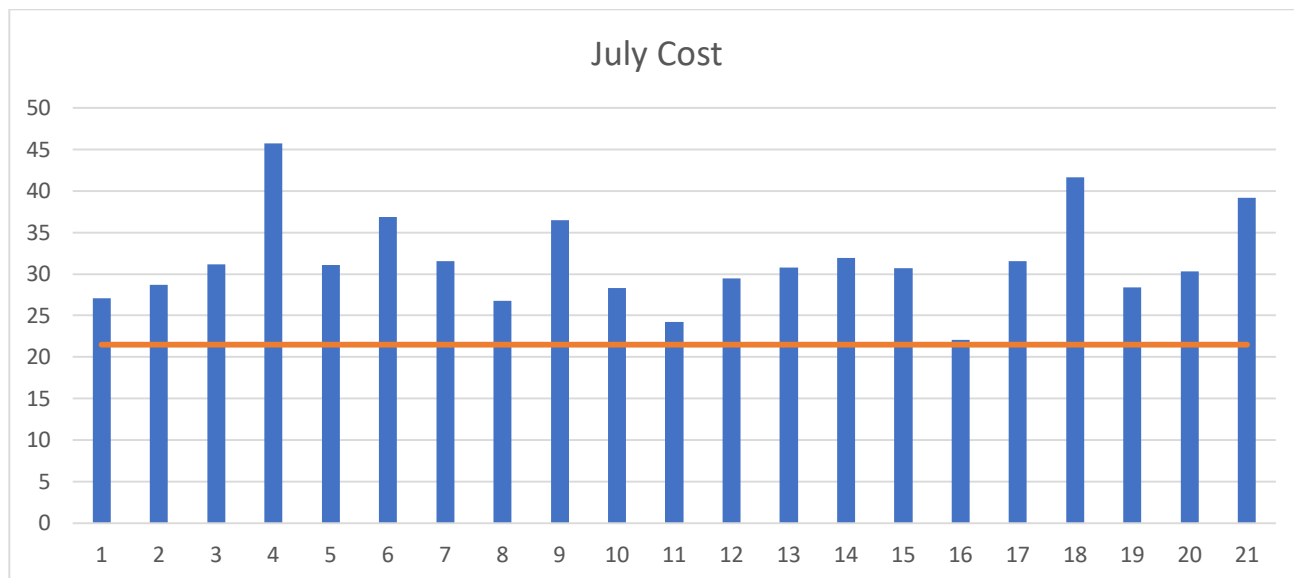
Figure C13: *July Daily Cost Data*
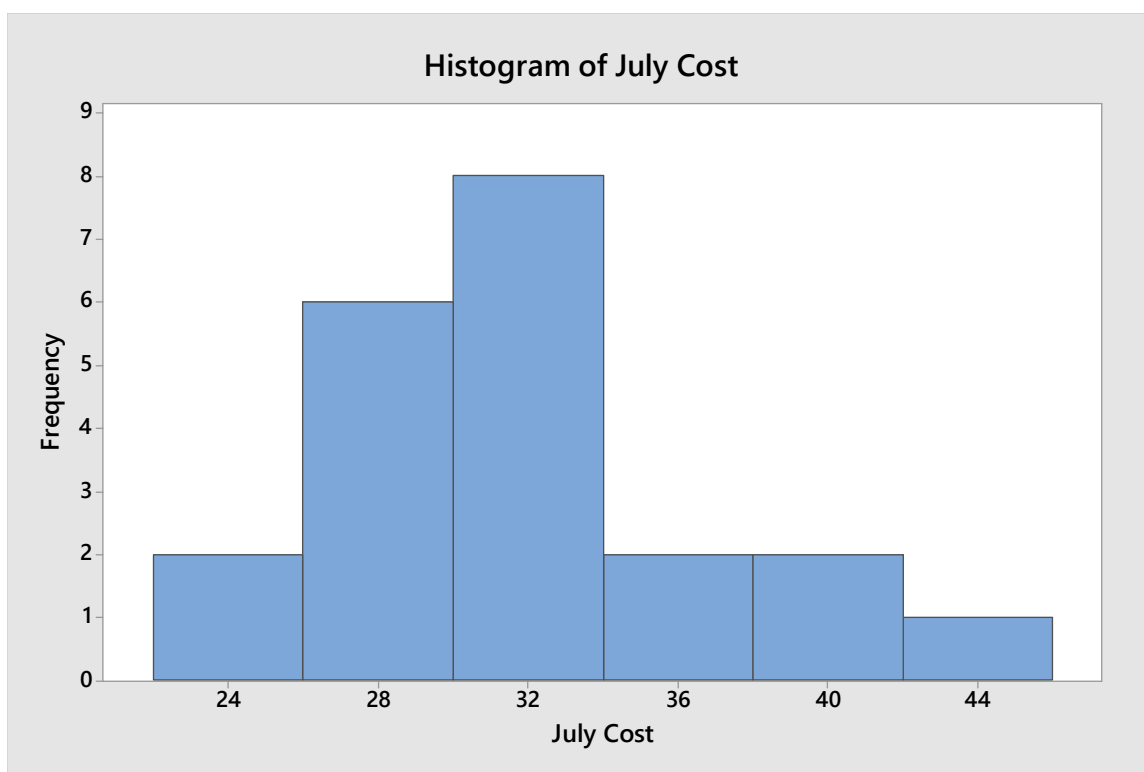
Figure C14: *July Daily Cost Histogram*
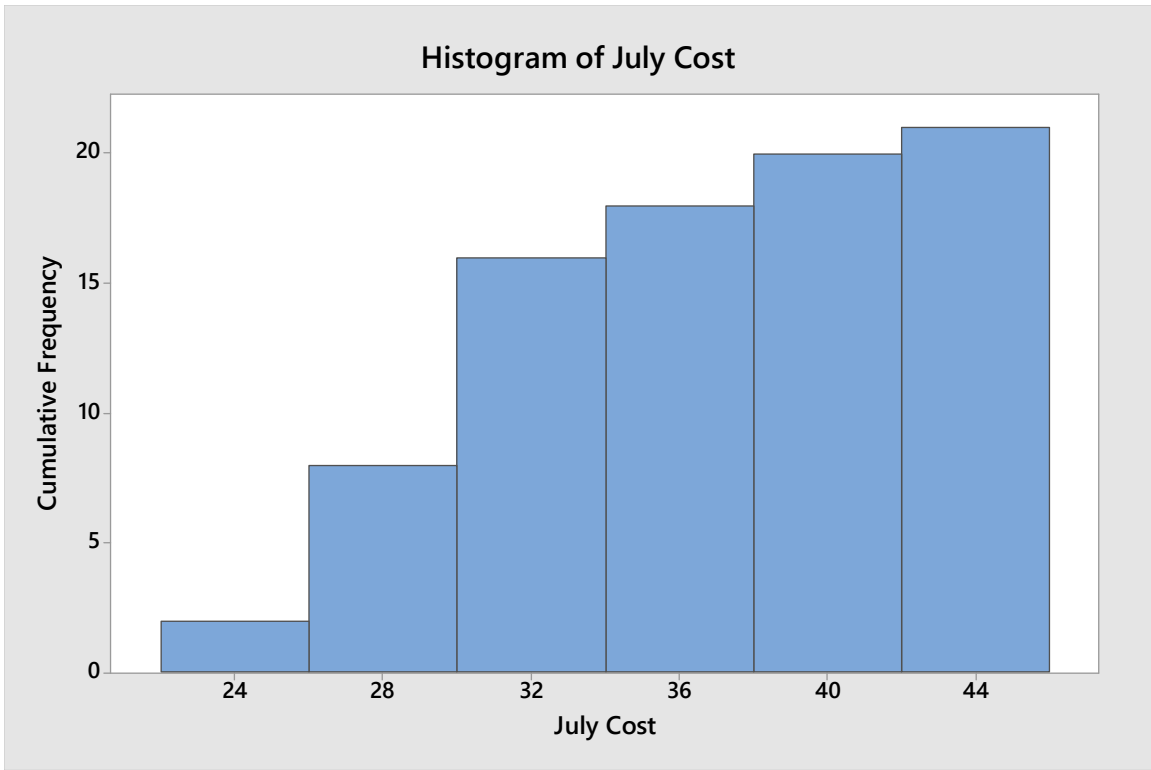
Figure C15: *July Daily Cost Cumulative Frequency Histogram*
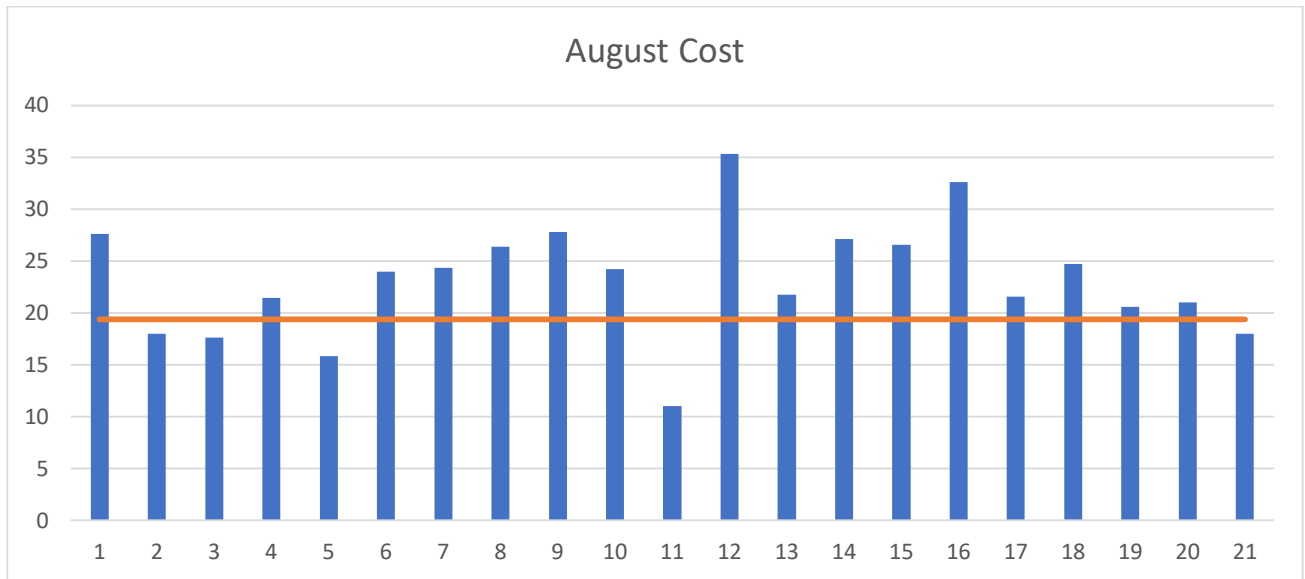
Figure C16: *August Daily Cost Data*
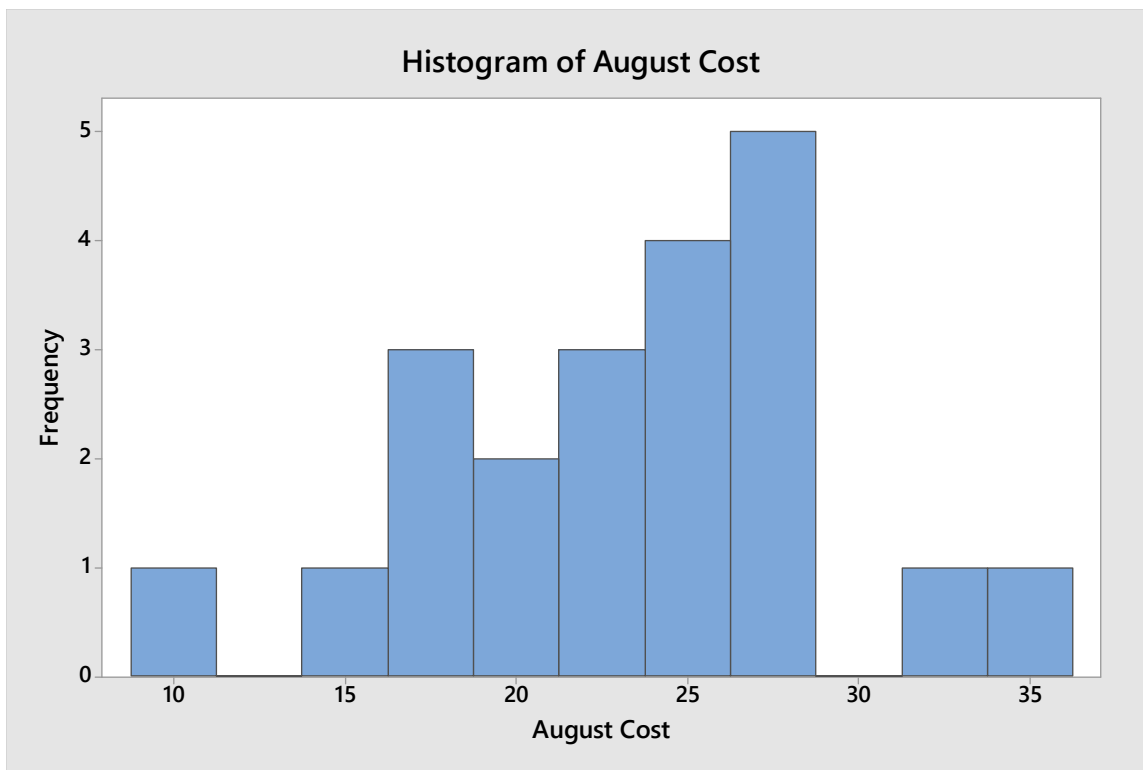
Figure C17: *August Daily Cost Histogram*
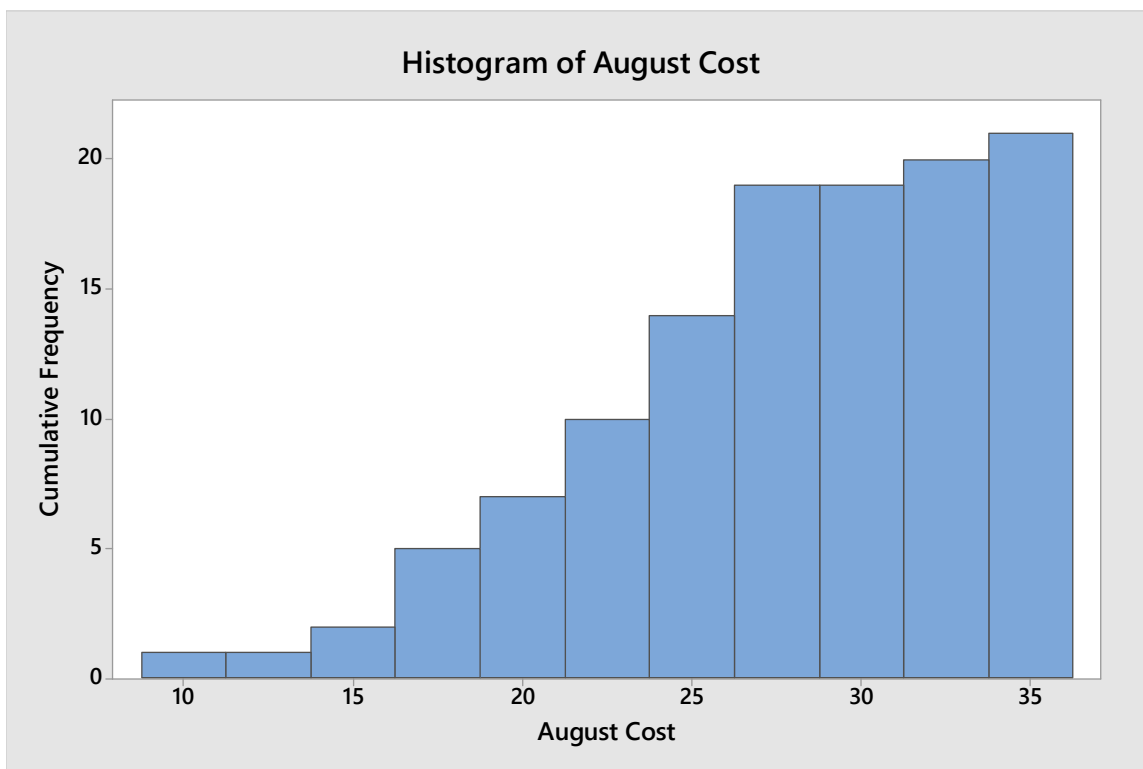
Figure C18: *August Daily Cost Cumulative Frequency Histogram*

Appendix D: Quality Analysis
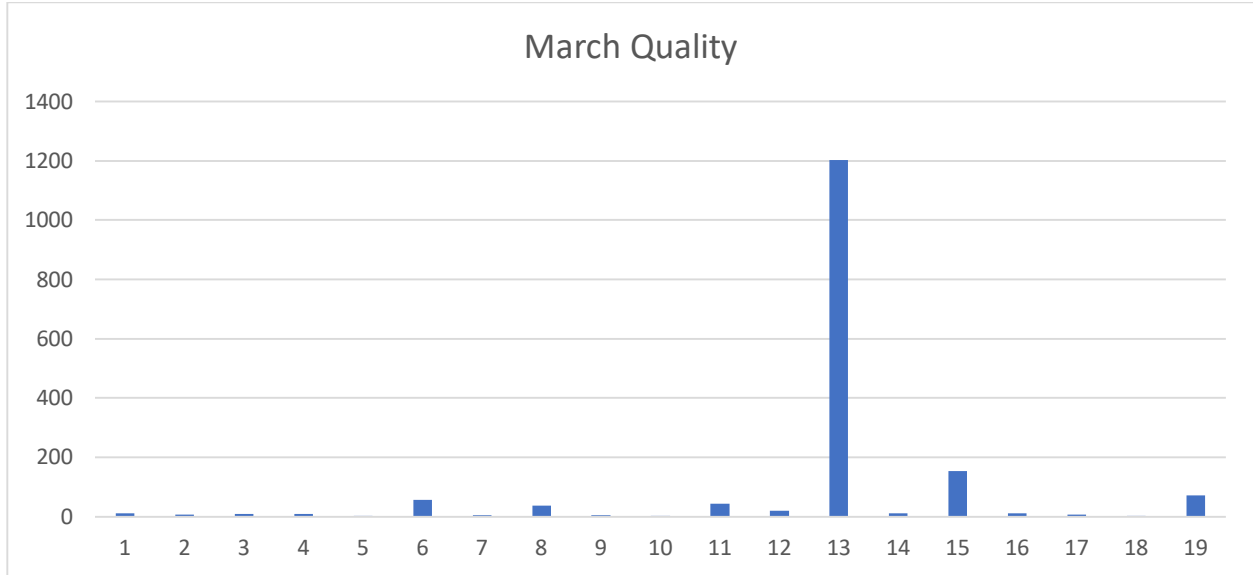
Figure D1: *March Daily Quality Data*
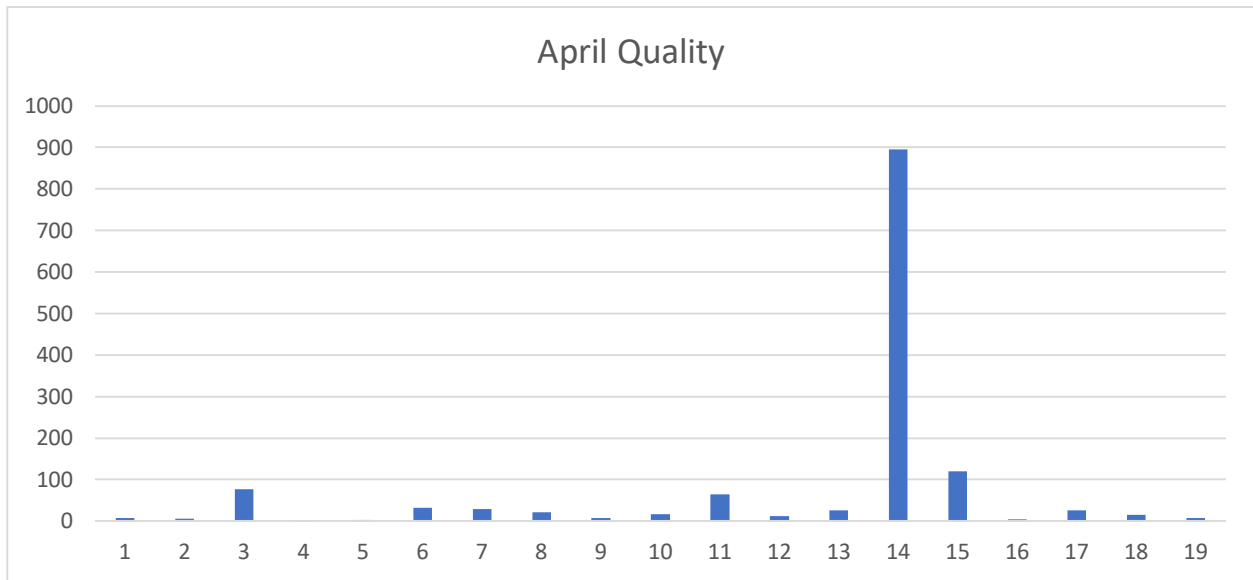
Figure D2: *April Daily Production Data*
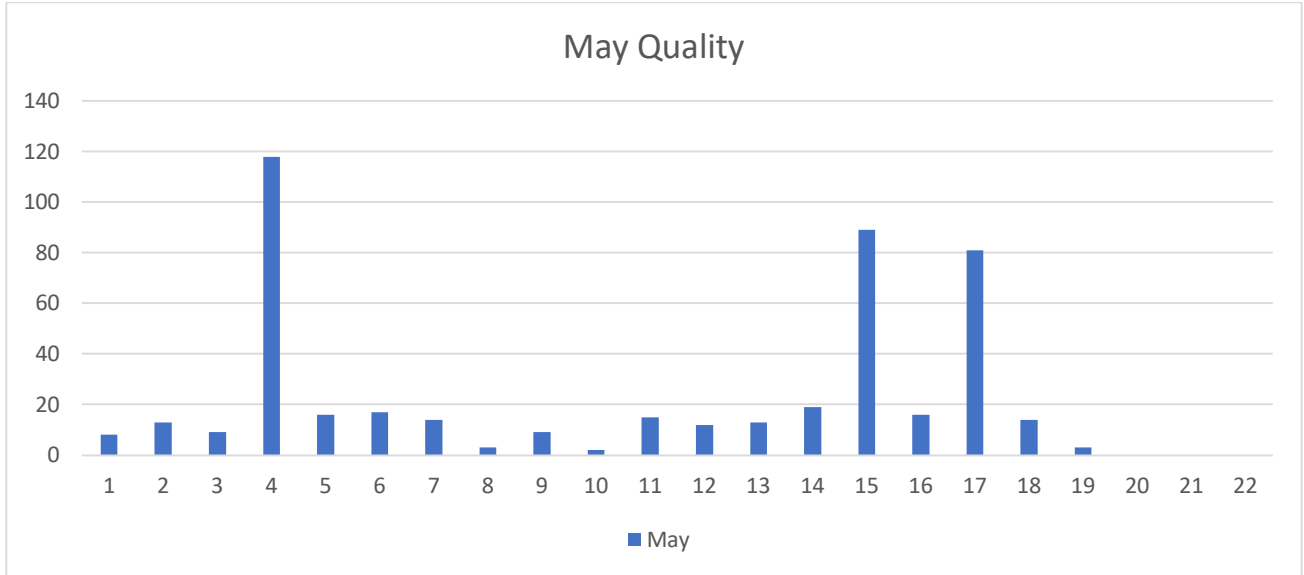
Figure D3: *May Daily Quality Data*
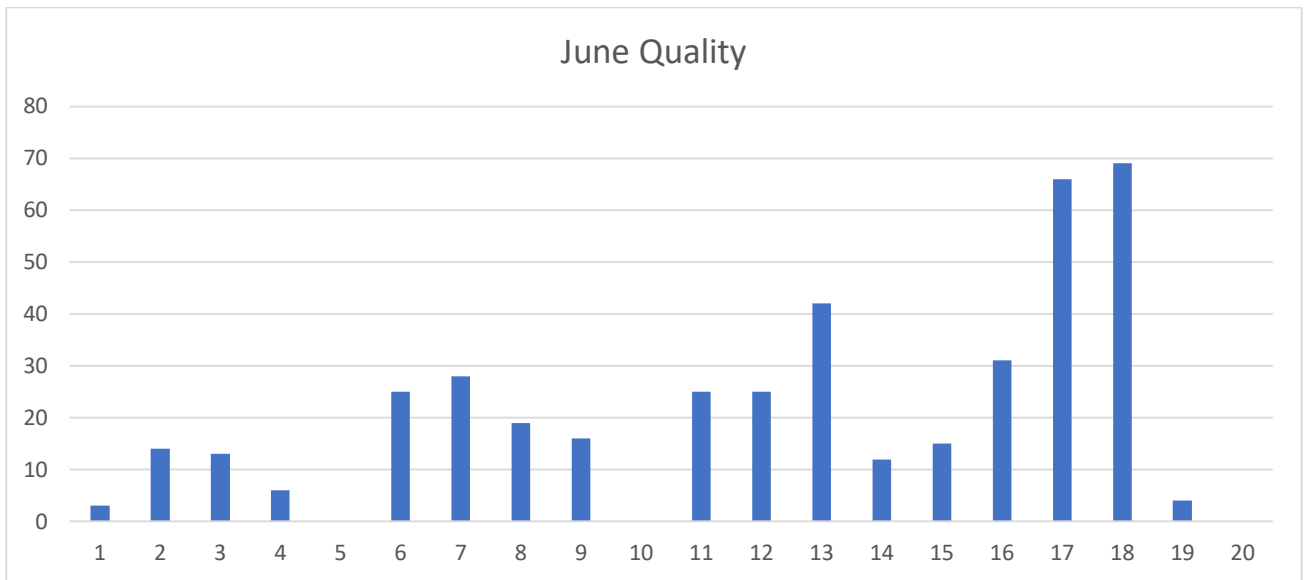
Figure D4: *June Daily Quality Data*
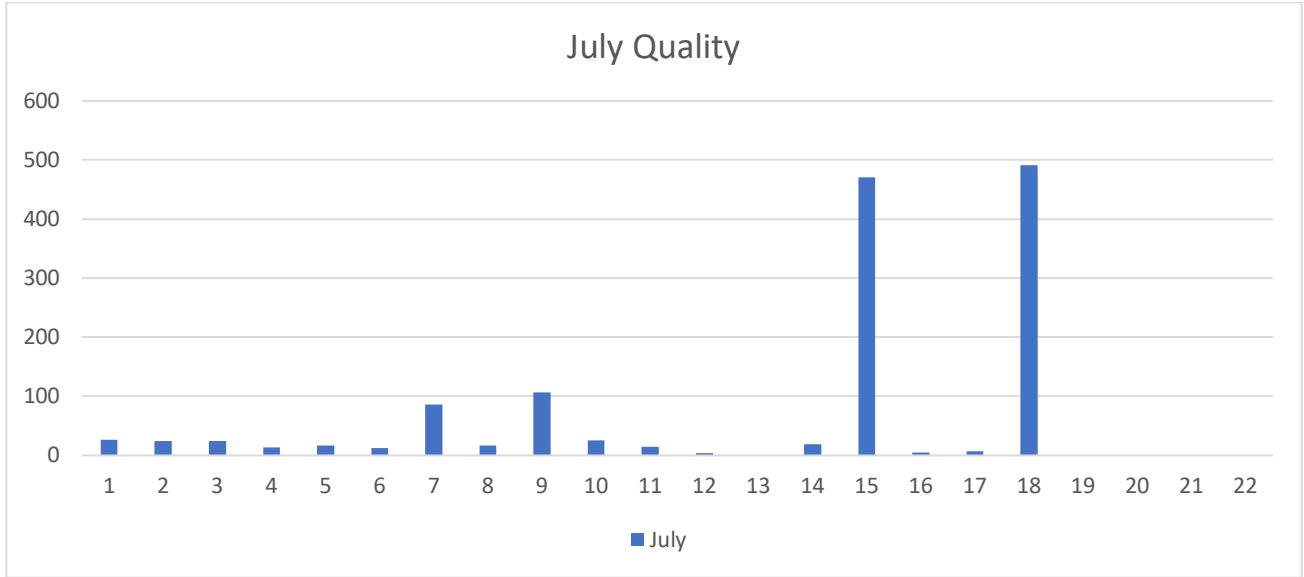
Figure D5: *July Daily Quality Data*
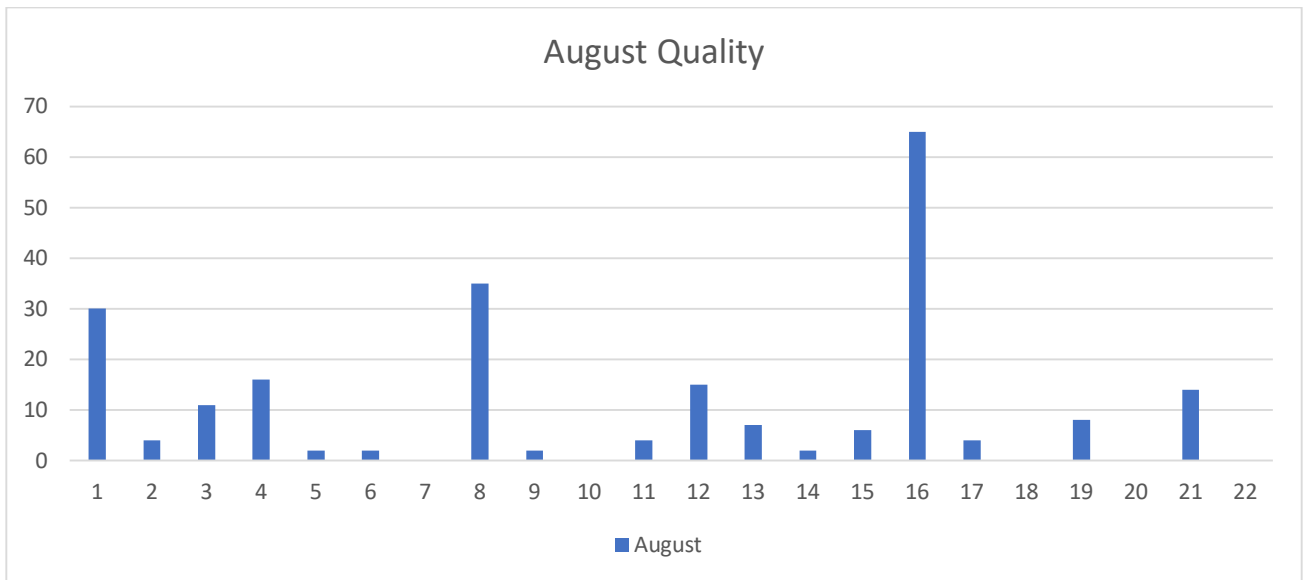
Figure D6: *August Daily Quality Data*

Appendix E: Process Analysis
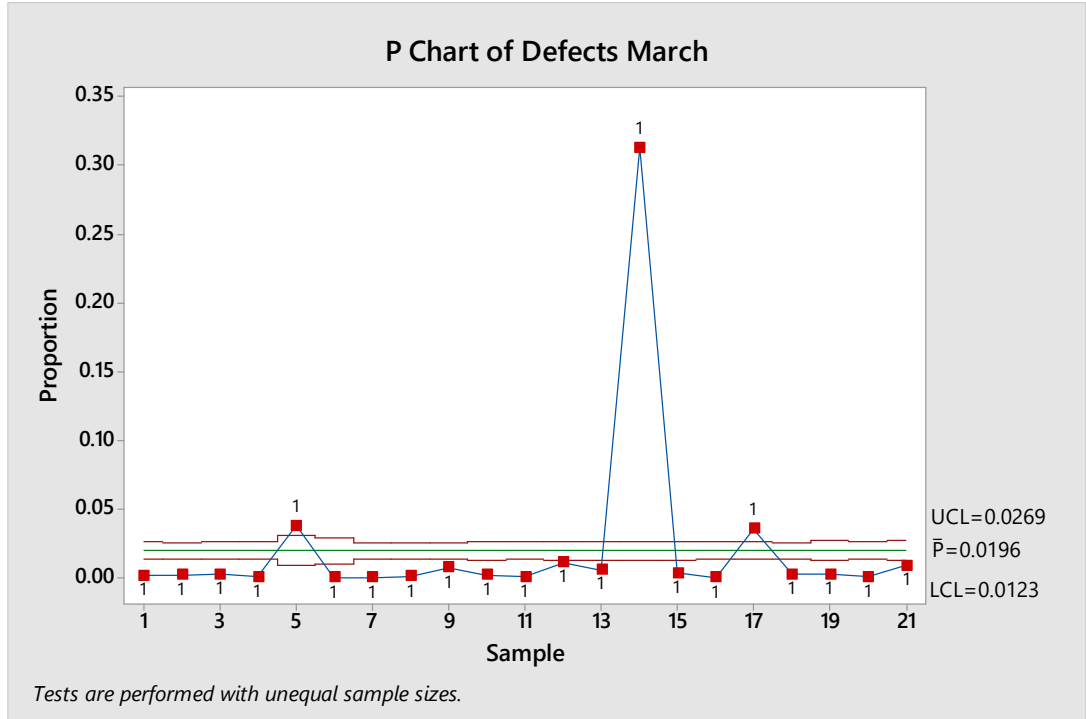
Figure E1: *March Daily Process P-Chart*
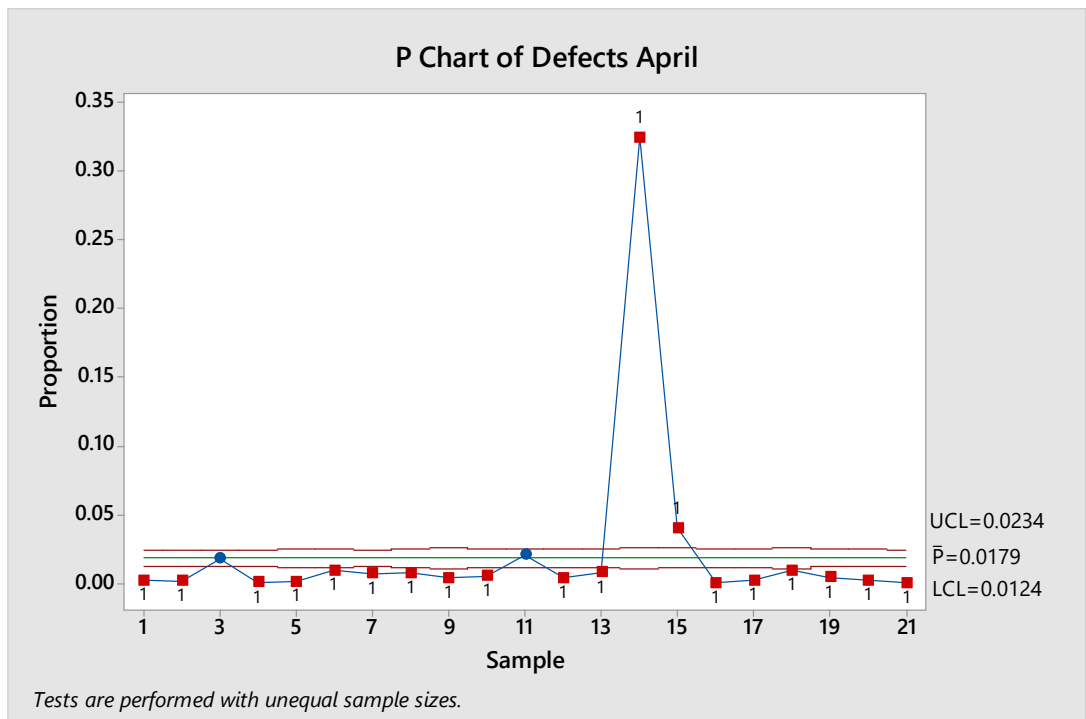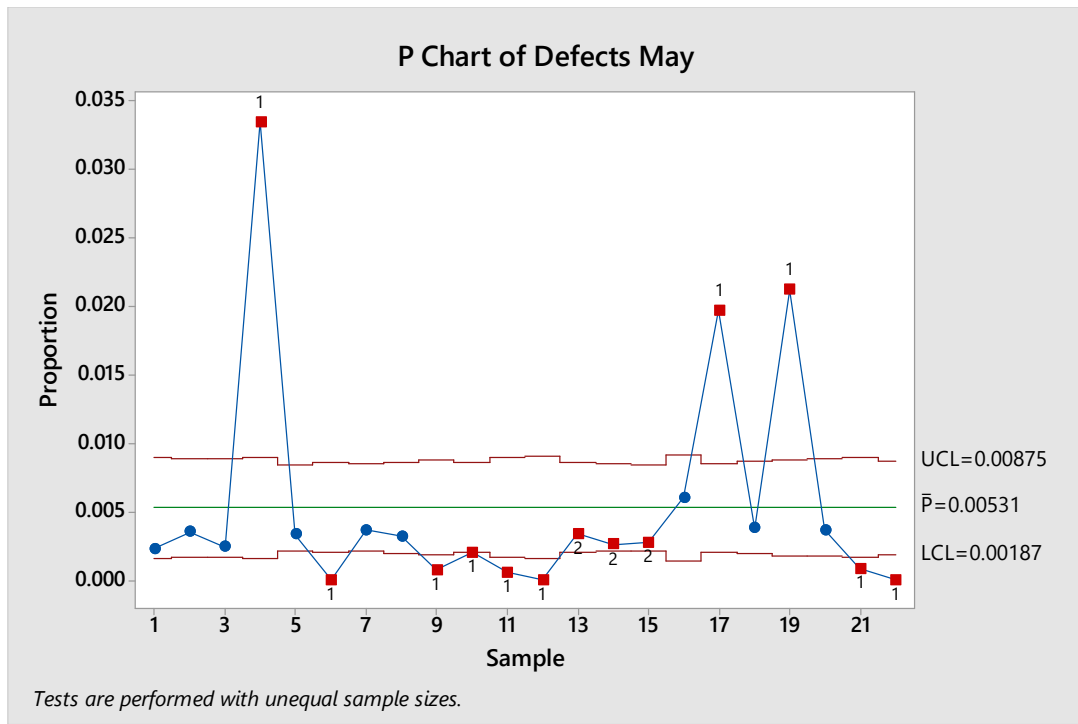

Figure E2: *April Daily Process P-Chart*

Figure E3: *May Daily Process P-Chart*
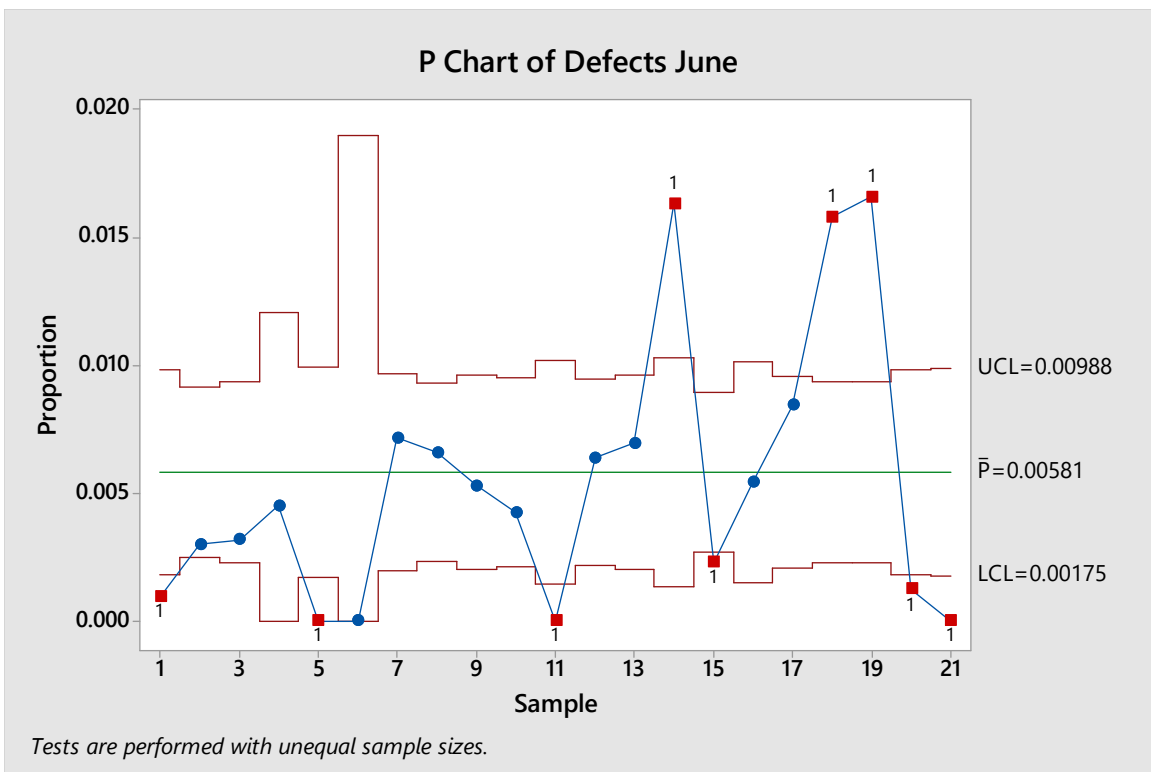
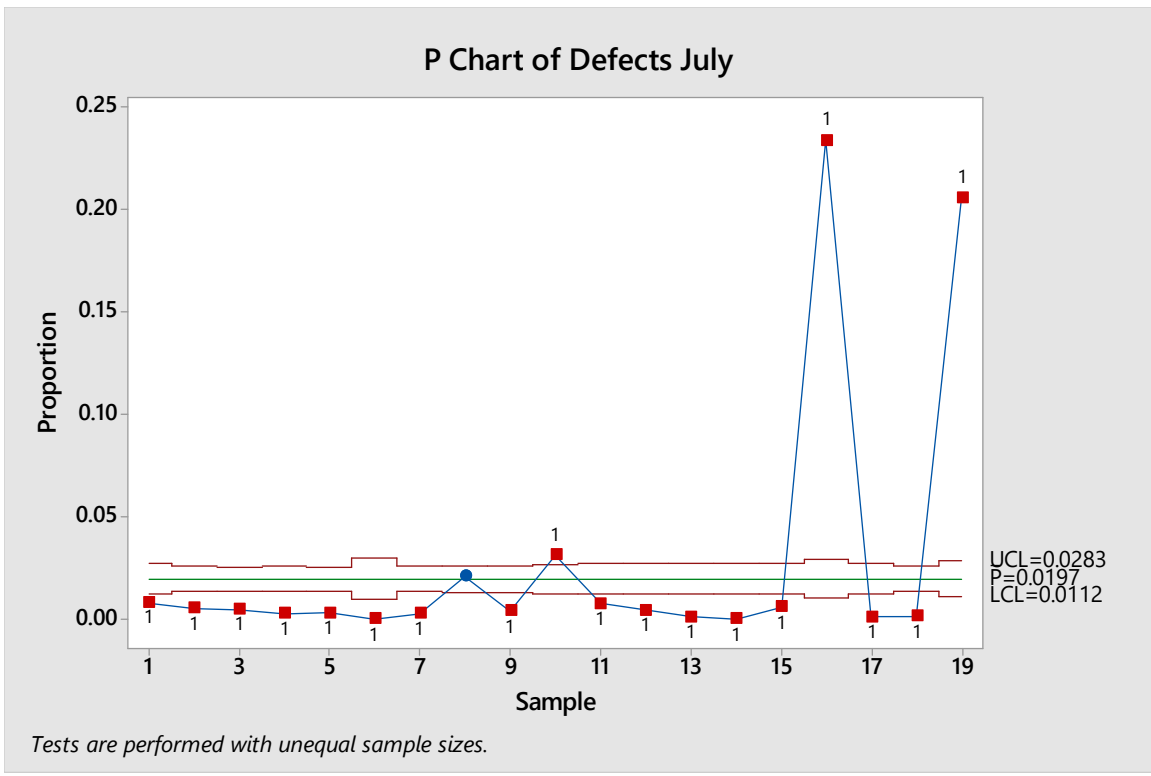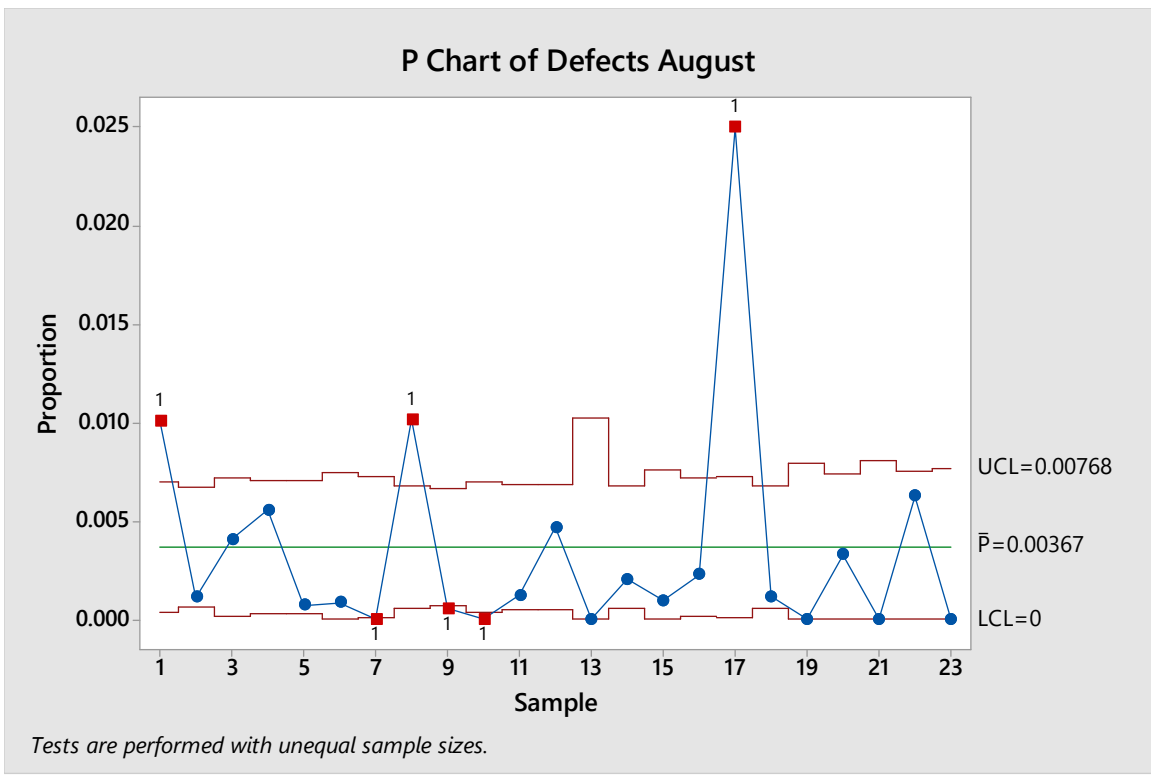***Figure E4:*** *June Daily Process P-Chart*

Figure E5: *July Daily Process P-Chart*

Figure E6: *August Daily Process P-Chart*