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# QUALITY IMPROVEMENT ON PIPE DEFECTS AT WELDING ERECTION PROCESS

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## ABSTRACT

The project was carried out at Aldats (Malaysia) Sdn. Bhd., located in Bandar Baru Seri Alam, Masai Johor. Aldats (Malaysia) Sdn. Bhd. offered three main services which are Engineering and Construction, Manpower Supply and Trading. Current pipe defect at engineering and construction services is 40% which in September 2022. The aim of this project is to reduce pipe defect at welding erection process by at least 20%. After the quality improvement by implement DMAIC, the result shows a decreasing to 27% in December 2022.

## 1.0 Introduction

The competitive environment of the construction industry has led many construction organizations toward using innovative methods [6]. Innovative methods may be used in order to improve the performance of the construction project by reducing project time and cost. Among those innovative methods, lean techniques have been used as an effective tool for minimizing waste by doing functions in proper time, and proper quantity by utilizing minimum resources.

Waste is defined as any activity or process that is not value added which means it does not add any value to the final product. The ultimate goal of lean methods is to eliminate waste and improve the value index of the processes. As a result, lean production systems try to produce at a lower time and cost compared with conventional systems by reducing or eliminating waste. This study aims to perform a Lean Six Sigma project by improving the delivery of products and services through continuous process improvement with the consideration of engineering technology project management, planning, and economic evaluations of quality improvement on pipe defects at welding erection process.

## 2.0 Literature Review

Lean Six Sigma (LSS) is a comprehensive long-term strategic decision-making strategy that increases value-added content while minimizing variation in quality and process characteristics, boosting customer satisfaction. Its goals are to promote customer happiness, speed up processes, and cut expenses [3]. LSS has been a popular continuous improvement (CI) approach [4,8,9] and it has been used by numerous public and private businesses such as BAE Systems Control and Northrop Grumman [5]. Its application in these situations has resulted in several benefits, including greater product quality, higher process reliability, reduced rework time, increased productivity, and increased system flexibility [1,2].
LSS embraces Define, Measure, Analyze, Improve, Control (DMAIC) and Define, Measure, Analyze, Design, Validate (DMADV) frameworks from six sigma. However, other variations of these roadmaps exist based on case-by-case customizations. The DMAIC methodology is the most widely used since it combines Six Sigma and Lean tools and techniques at critical phases of process improvement, whereas the latter concentrates on process (or product) design or redesign [7,10]. The DMAIC technique is the most effective approach for using LSS in an organizational context [11] for process improvement. Project charter, value stream maps, swim lane process maps, Gemba study, waste analysis, process capability analysis, Gauge R-R, cause-effect diagram, five-why analysis, statistical tests (like correlation, ANOVA), graphical tests (like Pareto charts, multi-vary charts), and so on are examples of commonly used DMAIC tools. LSS's structured problem-solving technique DMAIC calls into question the status quo of the process by stating certain fundamental claims such as;

- Define – What is the problem? Does it exist?
- Measure – How is the process measured? How is it performing?
- Analyze – What are the most important causes of defects?
- Improve – How do we remove the causes of the defects?
- Control – How can we maintain the improvements?

## 3.0 Define Phase – Define the Problem

The define phase is the first phase of Lean Six Sigma improvement process. In this phase, the project charter is developed based on the observation of the entire Welding Erection Process and begin to understand the needs of the customers. The charter captures basic project details, including opportunity statement, goal statement, project scope, project plan and team selection shown in Figure 1. Process mapping as shown Figure 2 revealed welding erection process. As process mapping is visually illustrate process activities it includes six main steps which includes: (1) Cutting process, (2) Welding process, (3) Storing process, (4) Welding process, (5) Testing process and
(6) Installation process.

**Business Case**

- Current pipe defect at engineering and construction services is 40%. Aim for this project is to reduce pipe defect at erection process by at least 20% that can save.

**Opportunity Statement**

- An opportunity to reduce pipe defect rework (20% of pipe defect) and reduce cost may be achieved by improving erection process. Erection process currently have contributed 25% out of 40% total pipeline defect at the construction site which is 2108 amount of pipes.

**Goal Statement**

- Y: To reduce pipe defect at erection process by at least 20%.
- X1(Metrics): Scorecard and baseline performance of pipeline defect.
- X2 (Targets): Reduce cost of rework and improve delivery time.
- X3 (Due date): 3 months.

**Project Scope**

- The project scope is at Erection Process which it start at Cutting and ends at Installation.

**Project Plan**

| Milestone | Start | End |
|---|---|---|
| Define | Week 1 | Week 4 |
| Measure | Week 3 | Week 8 |
| Analyse | Week 7 | Week 12 |
| Improve | Week 9 | Week 11 |
| Control | Week 11 | Week 13 |

**Team Selection**

- 6 group members
- 1 project supervisor

| Name | Responsibility |
|---|---|
| Aljhiemar bin Alnaib | Supervisor |
| Nur Edrinna Syafiqah binti Abdul Aziz | Project Leader |
| Mohamad Hafizuddin bin Mohamad Tajudin | Team Member |
| Nurul Fatini binti Ghazali | Team Member |
| Muhamad Faez bin Halimi | Team Member |
| Randall Gan Jia Ren | Team Member |
| Shahril Amirul Adly bin Nazri | Team Member |

Figure 1: Project Team Charter

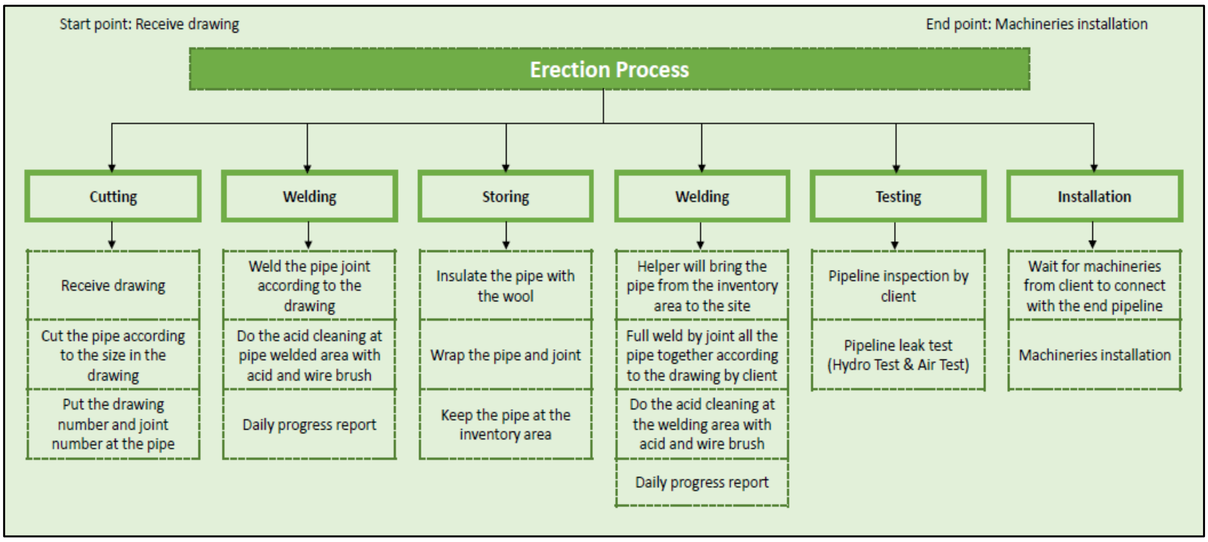



Figure 2: Process Mapping (Top-Down Charting)

## 4.0 Measure Phase – Map Out the Current Problem

In the measured phase, the team focuses on the data collection. Also focusing on two goals which are determine the start point on current performance of the process and understand the causes that might affect the issues of the process. Before data collection being done, a proper Data Measurement Plan is being prepared as shown in Figure 3. Data collected is focusing on the pipe rate defect on welding process over a period of 3 months. Out of 100% pipeline that went passed through the testing, 40% were reject because of pipe defect. 5% from material defect, 10% fabrication defect and 25% from welding erection defect. Consequently, a project to reduce pipe defect was finally approved by the management. At the outset, basic descriptive statistics was used to see the variation. The histogram in Figure 4 shows the variation in pipe defect. The team aimed for a target to reduce pipe defects by 20% in a 3 months' timeframe.

**Data Measurement Plan**

| Performance Measure | Operational Definition | Data, Sources & Location | Sample Size | Who Will Collect The Data | When Will Data Collected | How Will Data Be Collected | Other Data That Should Be Collected At The Same Time |
|---|---|---|---|---|---|---|---|
| Y: Total pipe defect at erection process | Pipe leakage captures every month | Aldats (Malaysia) site data collection | Monthly | Edrinna & Randall | Week 6 to 10<br>Starts at 14 Nov until 12 Dec 2022 | By checking on the part | Material of pipe, pipeline system affected & type of defect |
| X1: Working instruction as stated in operational system | Actual condition captured | Analysis, *Genba* observation & discussion with process owner | Monthly | Hafiz & Faez | | By checking on the process | |
| X2: Preventive maintenance report | Actual condition captured and previous historical data | | Monthly | Shahril & Fatini | | By checking on the report | |
| X3: Monthly periodic check | Actual condition captured and previous historical data | | Monthly | Shahril & Fatini | | By checking on the process | |
| X4: ASME welding standard | Actual condition captured | | Monthly | Hafiz & Faez | | By checking on the standard | |
| X5: Inventory control standard operating procedure | Actual condition captured | | Monthly | Edrinna & Randall | | By checking on the inventory | |

Figure 3: Data Measurement Plan

| System | Defect n (%) | | |
|---|---|---|---|
| | Pipe not straight | Weld area dirty | Pipeline leaking |
| Black Utility | 76 (1.44%) | 333 (6.33%) | 543.5 (10.33%) |
| HVAC | 105 (1.99%) | 139.5 (2.65%) | 559.5 (10.63%) |
| Process Drain | 83 (1.58%) | 80 (1.52%) | 55 (1.05%) |

**Descriptive Statistics: Black utility, HVAC, Process drain (Average)**

| Variable | N | N* | Mean | SE Mean | StDev | Minimum | Q1 | Median | Q3 | Maximum |
|---|---|---|---|---|---|---|---|---|---|---|
| Black utility | 3 | 0 | 318 | 135 | 234 | 76 | 76 | 333 | 544 | 544 |
| HVAC | 3 | 0 | 268 | 146 | 253 | 105 | 105 | 140 | 560 | 560 |
| Process drain | 3 | 0 | 72.67 | 8.88 | 15.37 | 55.00 | 55.00 | 80.00 | 83.00 | 83.00 |

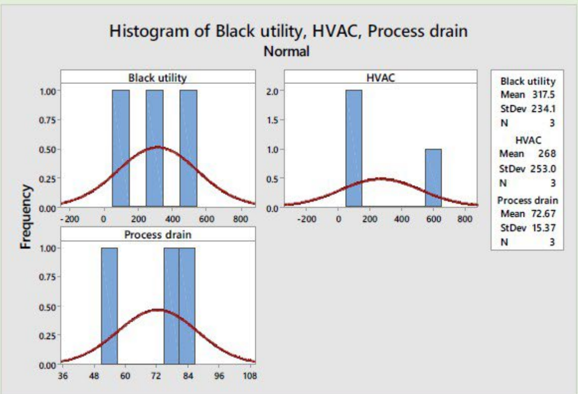



Figure 4: Histogram of Pipe Defect Variation

## 5.0 Analyze Phase – Identify Cause of the Problem

Potential causes of pipe defect were brainstormed, and visually shown using cause-and-effect diagram as illustrated in Figure 5. Five-Why analysis were used to drill the root causes of leading potential sources of each element. Multi-voting and discussion with the process owner in the company prioritized the three most prevalent causes which are not follow standard procedure, pipe not fully weld, and improper current setting as showed in Figure 6.

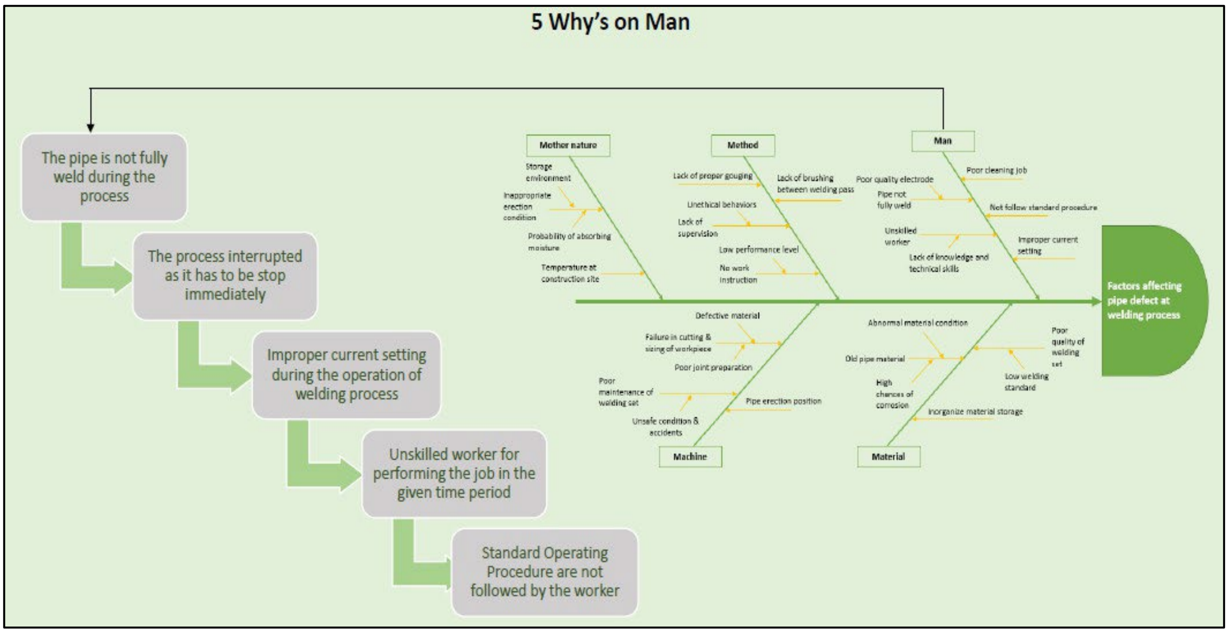



Figure 5: Cause-and-effect Diagram

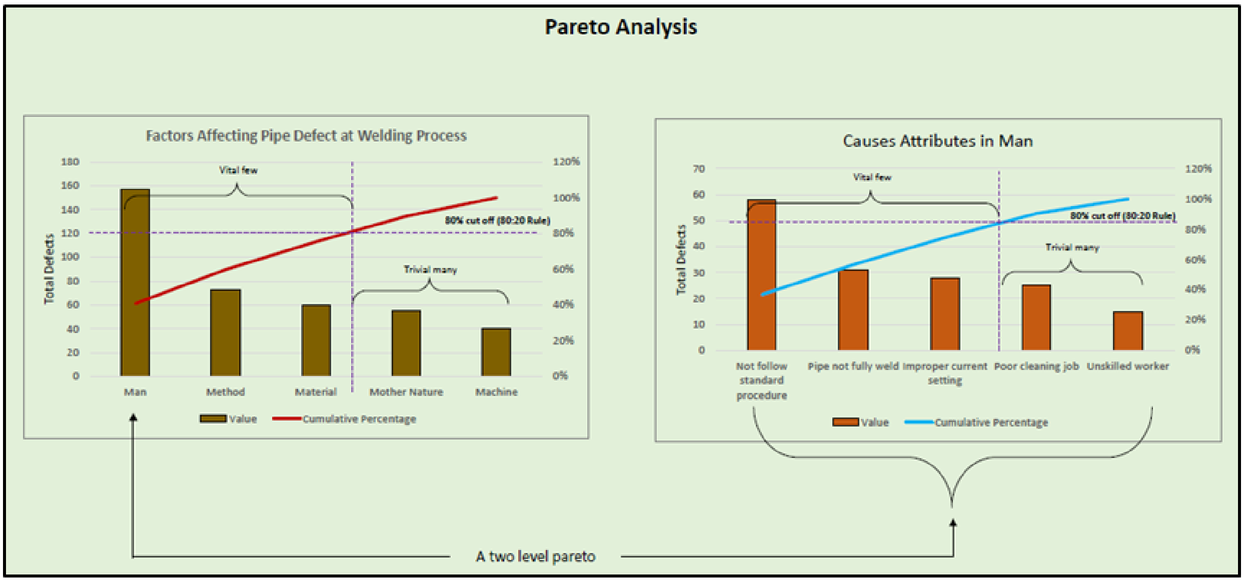



Figure 6: Two-tiers Pareto Analysis

## 6.0 Improve Phase – Implementation of the Solution

In cooperation with the process owner, researchers brainstormed potential solutions for the pipe defect that occurred during the welding erection process. Figure 7 illustrates the ranking of 4 out of 10 potential solutions using the selection criteria of sigma impact, time impact, and implementation cost. In addition, the highest ranking is 192. During the brainstorming process, suggestions for improvement including monitoring with drawing indicators, inspecting with necessary tests, Kaizen boards, and daily inspection reports were identified. As shown in Figure 8, after improvement through inspection report completion and inspection with necessary tests, the results of pipe defect are decreasing to 27%.

**Solution Evaluation Process**

**Solution Selection Matrix**

| | Selection criteria | | | | |
|---|---|---|---|---|---|
| | Sigma impact | Time impact | Implementation | Total score | Rating |
| Importance >> | 10 | 8 | 8 | | |
| Potential Solution | | | | | |
| Penalties towards the worker that not apply the working standard of procedure | 4 | 5 | 5 | 120 | 4 |
| The workers need to ensure that the pipe and welding machine is in a good condition | 6 | 6 | 7 | 164 | 2 |
| The quality department needs to check the whole pipeline system before the installation process | 8 | 7 | 7 | 192 | 1 |
| Each machine has to be supervised by the supervisor frequently to ensure that are no mistake during the production ongoing | 5 | 5 | 6 | 138 | 3 |

**Suggestion for Improvement**

- Monitor with drawing indicator
- Inspect with necessary tests
- Kaizen Board
- Daily Inspection Report

Figure 7: Solution Selection Matrix

**Pilot Selected Solutions**

**Data Collection – Pilot: Total Pipe Defect at Erection Process (December 2022)**

| Type of Pipe Material | Quantity of Pipe n (%) |
|---|---|
| August | 1831 (35%) |
| September | 2108 (40%) |
| October | 1894 (36%) |
| November | 1789 (34%) |
| December | 1421 (27%) |

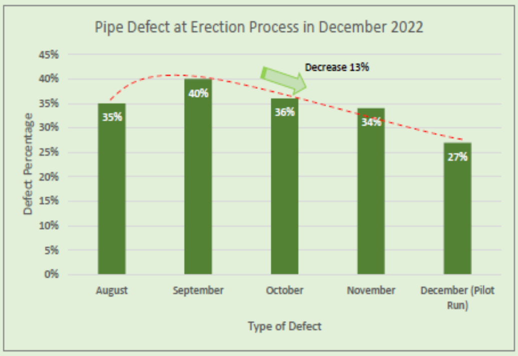
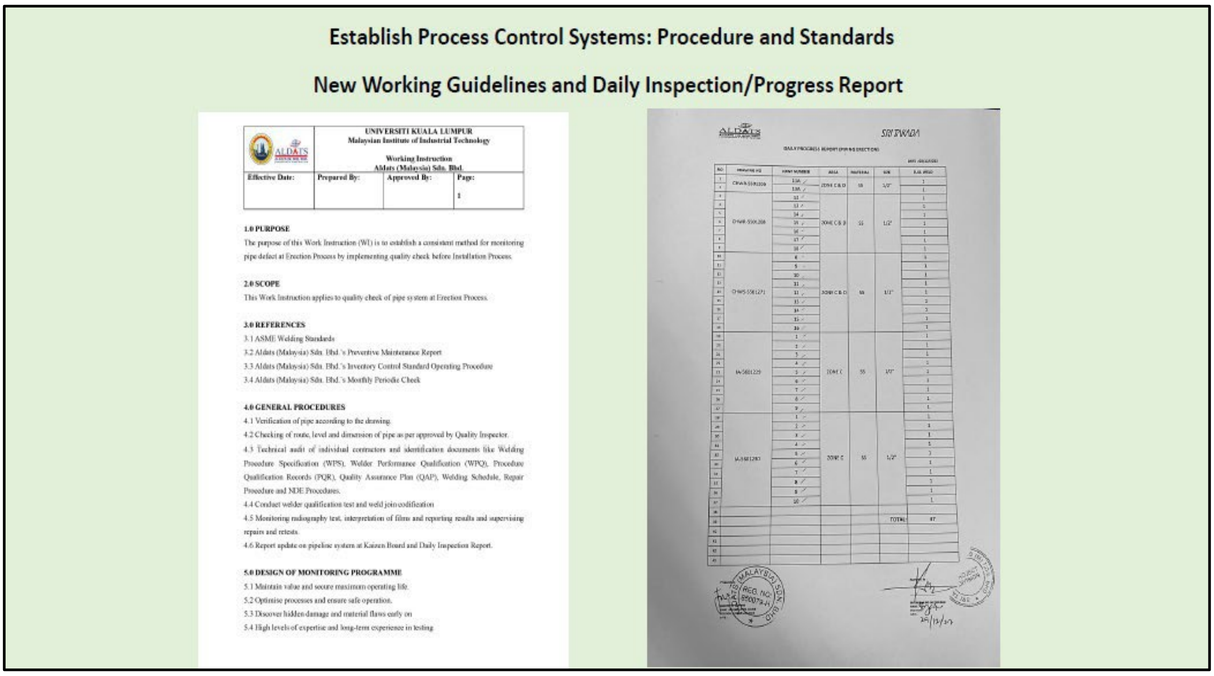



Figure 8: Defects After Improvement

## 7.0 Control Phase – Maintain the Solution

As shown in Figure 9, the solution implemented during the control phase includes new working guidelines to assist the company to maintain and sustain the solution. The daily inspection report was successfully implemented in the company as a solution.




| UNIVERSITI KUALA LUMPUR<br>Malaysian Institute of Industrial Technology<br>Working Instruction<br>Aldats (Malaysia) Sdn. Bhd. | | | |
|---|---|---|---|
| Effective Date: | Prepared By: | Approved By: | Page:<br>1 |

**1.0 PURPOSE**

The purpose of this Work Instruction (WI) is to establish a consistent method for monitoring pipe defect at Erection Process by implementing quality check before Installation Process.

**2.0 SCOPE**

This Work Instruction applies to quality check of pipe system at Erection Process.

**3.0 REFERENCES**

3.1 ASME Welding Standards
3.2 Aldats (Malaysia) Sdn. Bhd.'s Preventive Maintenance Report
3.3 Aldats (Malaysia) Sdn. Bhd.'s Inventory Control Standard Operating Procedure
3.4 Aldats (Malaysia) Sdn. Bhd.'s Monthly Periodic Check

**4.0 GENERAL PROCEDURES**

4.1 Verification of pipe according to the drawing.
4.2 Checking of route, level and dimension of pipe as per approved by Quality Inspector.
4.3 Technical audit of individual contractors and identification documents like Welding Procedure Specification (WPS), Welder Performance Qualification (WPQ), Procedure Qualification Records (PQR), Quality Assurance Plan (QAP), Welding Schedule, Repair Procedure and NDE Procedures.
4.4 Conduct welder qualification test and weld join codification
4.5 Monitoring radiography test, interpretation of films and reporting results and supervising repairs and retests.
4.6 Report update on pipeline system at Kaizen Board and Daily Inspection Report.

**5.0 DESIGN OF MONITORING PROGRAMME**

5.1 Maintain value and secure maximum operating life.
5.2 Optimise processes and ensure safe operation.
5.3 Discover hidden damage and material flaws early on
5.4 High levels of expertise and long-term experience in testing

Figure 9: Guidelines and Daily Inspection Report

## 8.0 Results

To ensure that the public and the environment are maintained, pipelines in construction sites are created and constructed in accordance with strict requirements. A pipeline may deteriorate over time to the point where a spill or release may happen due to human error, corrosion, and external factors. Normal testing procedures check that the pipe in the construction area has been welded according to the proper standards, however during fabrication, as a result of human errors, the pipe develops defects.

For the define phases, it contains the project team charter to define the focus, goals, direction and scope for the improvement team. The development of voice of the customer is to understand feedback highlighting the offerings that thrill, satisfy, and dissatisfy. Measure phase is to measure the process performance. The team constructed a data measurement plan to focus on the pipe rate defect on welding process for period of three months. From the observation, out of 100% pipeline that went passed through the testing, 40% were rejected because of pipe defect. 5% from material defects, 10% fabrication defect and 25% from welding erection defects. The histogram is used to shows the variation of the pipe defect.

The team brainstormed the potential causes of pipe defect using cause and effect diagram as a root cause analysis in analyze phase. This phase is the process to determine root causes of variation, poor performance (defects). In addition, the team for the improvement phase conduct with cooperation with the process owner by addressing and eliminating the root causes. The improvement focuses on the pipe defect at welding erection process. Based on the solution selection matrix, the suggestion for improvement is to monitor with drawing indicator, inspect with necessary tests, kaizen board and daily inspection report. After this improvement method, results of pipe defect are decreasing to 27%. Lastly, the team with consent of the process owner establishes the procedure and standards of new working guidelines and daily inspection / progress report.

## 10.0 Conclusion

The researcher would like to thank Aldats Malaysia Sdn Bhd for effectively assisting in the resolution of a pipe defect during the welding erection process at the company using the DMAIC approach, which achieved all of the objectives. Using the DMAIC define approach, the researcher understands the main problem and uses the measure methodology to determine whether or not it has a measurable value. As a result, the analysis approach assists in the detailed analysis of the problem that the organization is facing. The researcher's suggestion for improvement reduces the problem and can save the company money. The last approach is used to regulate and sustain the improvement method so that the problem is reduced repeatedly. In conclusion, the project implementation involves employing some quality tools and techniques that assist the organization in reducing costs and problems so that it can meet customer satisfaction on time.

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