Analysis of PCB Defects in the Reflow Soldering Process Using the PFMEA Method

Final Project

By:
Tanto Wijaya (3222211001)

Electronics Manufacturing Engineering Study Program
Electrical Engineering Department
Politeknik Negeri Batam
2025

Statement of Authenticity of Final Project

I, the undersigned, certify that the contents of part or all of my Final Project entitled: "Analysis of PCB Defects in the Reflow Soldering Process Using the FMEA Method" is my **own work**, **completed without the use of materials that are not permitted**, and **is not the work of other parties which I acknowledge as my own work.** All references cited or referred to have been written in full in the bibliography. If it turns out that my statement is not true, I am willing to accept sanctions in accordance with applicable regulations.

Batam, 25 April 2025

Tanto Wijaya
NIM: 3222211001

Approval sheet

The Final Project is structured to fulfill one of the requirements for obtaining a degree
Bachelor of Associate Engineer (AMd.T.)
in
Batam State Polytechnic

By:
Tanto Wijaya (3222211001)

Session date: 25 April, 2025

Approved by:

1.Ir. Fitriyanti Nakul, S.Pd., M.Si
NIK: 118197

2.Hana Mutialif Maulidiah, ST, M.Si .
NIK: 120241

1. Muhammad Arifin, S.Si., M.Si
NIK: 116161

Analysis of PCB Defect in the Reflow Soldering Process Using the PFMEA Method

Tanto Wijaya[1], Tanto Wijaya[1], and Muhammad Arifin[1*]
[1]Jurusan Teknik Elektro, Prodi Elektronika Manufaktur, Politeknik Negeri Batam

E-mail: arifin@polibatam.ac.id

Abstract— **This research analyzes errors in the reflow soldering process on Surface Mount Technology (SMT) with PFMEA method that often result in defects on printed circuit boards (PCB), such as tombstoning and bridging which can reduce production quality. The defects are caused by several factors, namely unstable temperature profile parameters, uneven use of solder paste, suboptimal stencil design, use of too much solder paste. Preventive solutions were implemented, including solder oven reflow calibration, squeegee function with good pressure when printing solder paste, optimal opening design, stencil mold volume. Monitoring results showed that these corrective actions reduced the production reject rate from 6.46% to 2.52% indicating the effectiveness of the measures taken.**

Keyword: PCB Component Defects, Reflow Soldering Process, Process Failure Mode and Effects Analysis (PFMEA).

I. INTRODUCTION

Today's electronics manufacturing industry relies heavily on Surface Mount Technology (SMT) technology to fulfill the need for fast, efficient, and high-quality production [1]. The demand for Surface Mount Device (SMD)-based devices continues to increase, thus driving major advancements in the SMT process. In this process, solder paste is applied to a Printed Circuit Board (PCB) using a stencil to form a solder joint pattern. Next, a pick-and-place machine places the SMD components onto the locations that have been coated with solder paste. The assembled PCB is then heated using a reflow soldering machine, which melts the solder paste creating a permanent bond between the SMD components and the PCB [2].

One of the important processes in Printed Circuit Board (PCB) production is the use of reflow soldering machines. The process of attaching Surface Mount Device (SMD) components that have been coated with solder paste to the PCB by melting the solder paste by heating it to a predetermined temperature to realize the electrical interconnection between the ends of the electrical components and the solder pads on the PCB using a reflow soldering machine [3].

II. METHOD

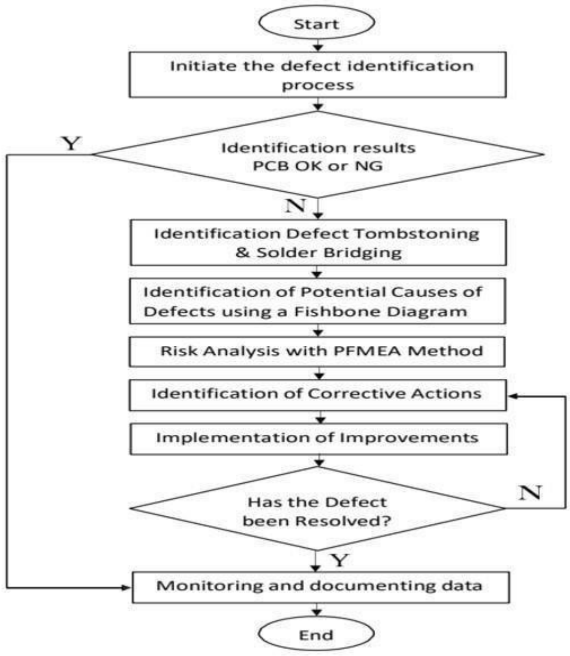

Figure 1. Flowchart Activity Analysis.

In completing the project "PCB Defect Analysis in the Reflow Soldering Process Using the PFMEA Method", a flow chart is needed to support the workflow to be carried out.

III. RESULT AND DISCUSSION

A. *Fishbone Diagram*

In figure 2, A cause-and-effect diagram, Ishikawa diagram, or Fishbone is a diagrammatic analysis tool used to identify the root causes of problems. In a Fishbone diagram, causes are divided into 5 to 6 root cause groups, starting with M [4]. The underlying problem can be placed in the right part of the diagram at the head of the fishbone, while the causes are placed in the fins and spines. The causes of the problem can be measurement, environment, method, material, human, and machine. All causes are kept definite to avoid undesirable, and PCB defects caused by reflow soldering machine.

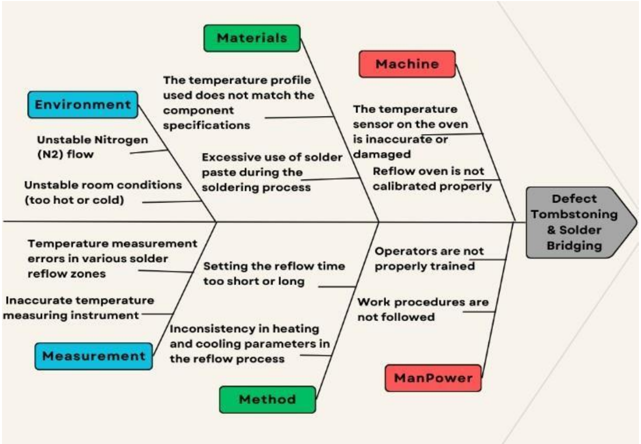

Figure 2. Fishbone Diagram.

Table 1. Fishbone Table.

No	Factor	Potential	Contributor (Yes/No)
1	Measurement	-Inaccurate temperature measuring instrument	No
		-Temperature measurement errors in various solder reflow zones	No
2	Environment	-Unstable room conditions (too hot or cold)	No
		- Unstable flow of Nitrogen (N2)	No
3	Material	-Excessive use of paste solder during the soldering process	Yes
		-The temperature profile used does not match the component specifications	No
4	Method	-Inconsistency in heating and cooling parameters in the reflow process	Yes
		-Setting the reflow time too short or long	No
5	Machine	-Reflow oven is not calibrated properly	No
		-The temperature sensor on the oven is inaccurate or damaged	No
6	Man Power	-Operators are not properly trained	No
		- Work procedures are not followed	No

Based on the verification results, the author concludes that PCBA defects are caused by two potential factors, namely material factors and method factors. The following is an explanation of the two potential factors (YES) and an explanation of the potential factors that did not contribute (NO) in Table 1.

1. *Measurement (NO)*

Inaccurate temperature measuring instrument: An inaccurate temperature measuring device (Thermocouple) can cause the reflow process to not run according to the desired temperature profile [5].

Temperature measurement errors in various solder reflow zone: If the temperature profile in each zone in the reflow oven (preheat, soak, reflow, cool down) has its own temperature control. A measurement error in any of the zones may cause the temperature profile to be out of specification [6].

Based on the analysis, the measuring instruments and measurement systems used do not show any direct contribution to the defects under study.

2. *Environment (NO)*

Unstable room conditions (too hot or cold): Reflow ovens are generally enclosed and have good internal temperature control. Room temperatures that are too high or low can affect the performance of the machine. Unstable Nitrogen (N2) flow: If N2 is used to maintain an inert environment, unstable nitrogen flow can cause oxidation of the solder joint process [7], [8].

Based on the analysis, there is no strong indication that environmental factors play a direct role in soldering defects that occur in the reflow soldering process.

3. *Material (YES)*

Excessive use of paste solder during the soldering process: Excessive use of solder paste can cause bridging (short circuit between component legs) [8]. The temperature profile used does not match the component specifications; If the profile is appropriate for most of the components or only a few components are not appropriate, then the impact is not significant. Or maybe the profile has been validated before [9].

Based on the analysis, Excessive use of solder paste can potentially cause defects that occur at the joints between two or more pads or pins on SMD PCBs.

4. *Method (YES)*

Inconsistency in heating and cooling parameters in the reflow process: Inconsistency in heating and cooling can cause the solder to not stick perfectly or cause tombstoning [10], [11], [8]. Setting the reflow time too short or long: As long as the total time is within tolerance and does not cause the soldering to overheat or cool down, then the reflow duration itself may not be the main cause [9].

Based on the analysis, there is a problem in the parameter profile of the reflow process that is not well controlled. Inconsistencies in heating and cooling parameters can lead to incomplete solder melting or unbalanced tensile forces.

5. *Machine (NO)*

The re-flow oven is not calibrated properly: If the oven is not calibrated and the process temperature results show that it does not match the specified standard. The temperature sensor on the oven is inaccurate or damaged: If there is a faulty sensor, it will usually be immediately apparent from the oven performance or system alarm, so it can be dealt with quickly [6].

Based on the analysis, the Reflow oven has been calibrated regularly and the sensor is still functioning properly, so the machine is not the main contributing factor.

6. *Man Power (NO)*

Operators are not properly trained: Untrained operators can make mistakes in the process setup [12]. Work procedures are not followed: Work procedures that are not followed can lead to inconsistencies.

Based on the analysis, there is no indication that operator error is a contributing factor in the production process failure.

B. Process Failure Mode and Effect Analysis (PFMEA)

PFMEA is one of the systematic methods used to identify, analysis, and mitigate potential risk failure problems in systems, processes, products, and services before they occur [13]. PFMEA is a structured procedure to identify and prevent as many causes of failure as possible. PFMEA is used to identify the source and root cause of quality problems [14]. PFMEA is done by recognizing and evaluating the potential failure risks and impacts of a product [15],[16].

C. Data analysis in PFMEA Table

1. *Solder Bridging*

Table 7 shown is part of the PFMEA analysis used to identify and evaluate potential failures in the Reflow Soldering process, specifically the Solder Bridging failure type.

In the Reflow Soldering process, there is a potential failure in the form of Solder Bridging defects. Errors at this stage can cause serious defects in the final product. The solder paste condition not only sticks to one pin of the component, but also bridges to the surrounding pins, thus causing a short circuit [8]. This condition is caused by excessive solder paste distribution. This indicates that the impact of the failure is quite severe.

During the production process, based on observations on the machine engineering line, it was found that the high number of defect events on PCBA affected the quality of the final product and required rework. The high incidence of defects has an impact on reducing the quality of the daily output that has been determined can cause major disruptions to services, especially involving client interactions questioning production consistency. In the PFMEA 1-10 rating scale for severity, this failure mode is rated 8.

The potential causes of this failure identified two main potential causes excessive solder paste printing when the amount of solder paste printed exceeds the predetermined limit, and sub-optimal stencil design inappropriate aperture size can lead to uneven distribution of solder paste. In the PFMEA scale for occurrence assessment, In the PFMEA assessment scale 1-10 for occurrence rate is rated 7, which indicates a high probability of failure as it relates to machine process control and design.

To detect these failures, an Automated Optical Inspection (AOI) machine with a minimum measurement size of 25M CXP Camera: 7.7 µm, and a microscope with optical resolution ≥ 2 µm/pixel and optical magnification of 40x-80x. In the PFMEA scale for detection, the given value is 4, which means that the detection system is sufficiently capable of detecting the failure mode. Therefore, the preliminary risk value (RPN) is calculated as Severity (8) × Occurrence (7) × Detection (4) = 224.

Recommended actions to reduce the possible causes of this issue include solder paste printing calibration and stencil design optimization. The party responsible for ensuring that these actions are properly implemented is the technician.

Corrective actions that have been taken include more even distribution of solder paste and optimizing the distance between the trace and the pad. After the actions were taken, severity was assigned a value of 5 (minor annoyance involving no direct interaction with the client), occurrence was assigned a value of 6 (medium probability of failure), and detection was assigned a value of 7 (low detectability). Thus, the final risk value (RPN) is calculated as Severity (5) × Occurrence (6) × Detection (7) = 210.

2. *Tombstoning*

Table 7 shows part of the PFMEA analysis in the Reflow Soldering process, specifically the Tombstoning failure type. In the Reflow Soldering process, one of the potential failure modes is Tombstoning, which is a condition where the solder paste is uneven and one of the legs of the end of the chip component is lifted from the PCB surface so that it resembles the position of a tombstone [11], [8].

During the production process, based on observations in the mechanical engineering line, it was found that the high incidence of defects in PCBA affected the quality of the final product and required rework. The high incidence of defects results in a decrease in the quality of the daily output that has been set, which can cause major disruptions to the service, especially involving client interactions that question the consistency of production to the production and engineering teams. In PFMEA's 1-10 rating scale for severity, this failure mode scores an 8.

The potential causes of this failure identified two main potential causes which are unstable temperature profile and uneven solder paste. In the PFMEA 1-10 rating scale for occurrence rate it is rated 6, which indicates a moderate probability of failure due to the machine's process control and design.

To detect this failure, an Automated Optical Inspection (AOI) machine with a minimum measurement size of 25M CXP Camera: 7.7 µm, and a microscope with optical resolution ≥ 2 µm/pixel and optical magnification of 40x-80x shown in Figure 12. In the PFMEA scale for detection, the given value is 4, which means the detection system is sufficiently capable of detecting the failure mode. Therefore, the preliminary risk value (RPN) is calculated as Severity (8) × Occurrence (6) × Detection (4) = 192

Recommended actions to mitigate the possible causes of this issue include stabilizing the reflow temperature profile with predefined solder paste standards and optimizing the stencil design. The party responsible for ensuring that these actions are properly implemented is the technician.

The corrective actions that have been taken are an optimized temperature profile with predefined standards and optimization of the distance between the trace and the pad. After these actions, severity scored 5 (minor disruption that does not involve direct interaction with the client), occurrence scored 6 (medium probability of failure), and detection scored 6 (low detectability). Thus, the final risk value (RPN) is calculated as Severity (5) × Occurrence (6) × Detection (6) = 180.

1) Data collection

Data collection was carried out by recording the number of defective products (rejects) in the PCBA production process for five weeks, starting from the 3rd week of December 2024 to the 3rd week of January 2025.

Table 2. Number of failed PCBA Products Before Action.

Production Time	Good (pcs)	Reject (pcs)	Total (pcs)	% Reject
3rd Week of December 2024	4970	280	5250	5,33%
4th Week of December 2024	6510	490	7000	7,00%
1st Week of January 2025	3360	140	3500	4,00%
2nd Week of January 2025	8060	690	8750	7,89%
3rd Week of January 2025	1420	80	1500	5,33%
Total	24320	1680	26000	6,46%

Based on the data in Table 2 above collected before corrective actions were taken, the number of defective PCBA products was recorded for five weeks, starting from the 3rd week of December 2024 to the 3rd week of January 2025. The data shows that the rejection rate varied each week, with the highest percentage occurring in the 2nd week of January 2025 at 7.89% and the lowest in the 1st week of January 2025 at 4.00%. Overall, the average reject rate before corrective action was 6.46%. This high percentage of rejects indicates instability in the production process that needs to be immediately identified and corrected to meet the expected quality standards [17].

Table 3. Number of Defective units in production Before Action.

Production Time	Total Units (pcs)	Total Defective Boards (pcs)	Type of Defect					Total Defective Component (pcs)
			Bridging	Tombstoning	Shifting	Insufficient Solder	Solder Balls	
3rd Week of Dec 2024	5250	280	96	80	68	52	38	334
4th Week of Dec 2024	7000	490	146	125	106	87	69	533
1st Week of Jan 2025	3500	140	84	58	36	28	18	224
2nd Week of Jan 2025	8750	690	198	178	165	105	86	732
3rd Week of Jan 2025	1500	80	41	28	17	13	9	108
Total	26000	1680	565	469	392	285	220	1931

Based on the data in Table 3 before corrective action is taken, it shows component defects detected in the AOI (Automated Optical Inspection) machine process per week for PCB Model X, with an observation period from week 3rd of December 2024 to week 3rd of January 2025. The total PCBA defects detected were 1680 pcs from a total output of 26000 pcs, so the total component defects detected by the AOI machine from week to week were 1931 pcs of component defects for five weeks before repairs were made which is the overall data from the detected defects. It can be concluded that the number of component defects detected is more than the number of PCBs detected on the AOI machine in 1 PCB panel. In 1 defective pad there are more than 1 component defect detected by the AOI machine. Week 2nd of January 2025 shows the worst performance with a high production quantity (8750 pcs) but the highest number of defects (732 pcs). Bridging and Tombstoning are the two main defect types that need to be analyzed further.

The following is a Pareto Chart of PCBA production data collection and component mode defect data collection for 5 weeks, starting from the 3rd week of December 2024 to the 3rd week of January 2025.

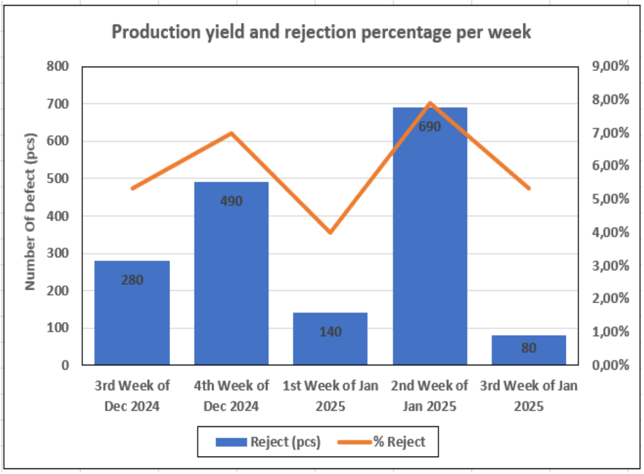

Figure 3. Production yield and rejection percentage per week Before Action.

Based on the Pareto Diagram in Figure 3 before corrective action is taken, it shows the number of rejected product pcs and the percentage of rejects in the production process with a span of five weeks from Week 3rd December 2024 to Week 3rd January 2025. The highest number of rejects occurred in the 2nd week of January 2025 as many as 690 pcs with a percentage of (8.0%), while the lowest occurred in the 3rd week of January 2025 which was 80 pcs with a percentage of (5.6%). The fluctuation in the number and percentage of rejects each week indicates instability in the production process. This needs to be analyzed further to find the root cause and prevent recurring defects.

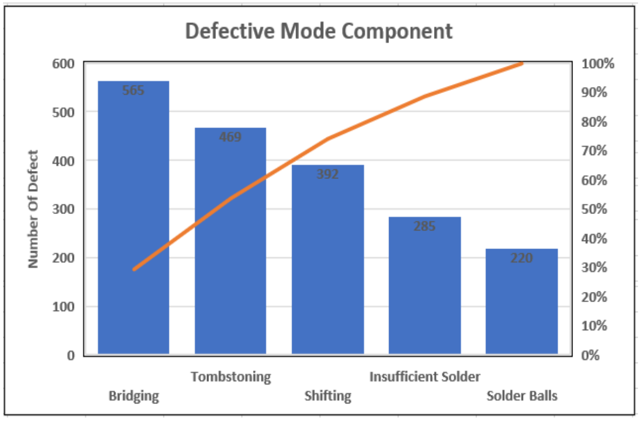

Figure 4. Defective Mode Component Before Action.

Based on the Pareto Diagram in Figure 4 shows the number of defects based on the type or mode of defects in the PCB production process before corrective action is taken. There are five types of defects, From the diagram it can be seen that Bridging is the most dominant type of defect with a total of 565 pcs, followed by Tombstoning with a total of 469 pcs. The cumulative curve (orange color) shows that the first two defect types (Bridging and Tombstoning) account for more than 80% of the total defects. This indicates that the focus of improvement should be prioritized on these two main defect types, in accordance with the 80/20 Pareto principle which states that most problems (80%) are usually caused by a small percentage of causes (20%).

2) Identify causes

PCBA defects are caused by two main factors: excessive paste solder usage and unstable temperature profile parameters. Sub-optimal stencil design occurs when the size or design of the stencil opening is inappropriate or too large at the PCB pad size position, which can cause excessive solder paste discharge and result in defects such as bridging.

The second factor relates to unstable temperature profile parameters on the reflow soldering machine with heating that is too fast or non-uniform can cause one side of the solder to melt first, making the component results rise at one end and uneven soldering. Temperature differences between areas within the reflow soldering oven can also cause variations in solder paste melting.

3) Process Improvement

After the indication of the cause of the PCBA defect is found. To prevent the occurrence of such PCBA defects, the recommended action is to perform stencil calibration on solder paste printing by ensuring accurate solder paste printing and optimizing the stencil design. Prevention by stabilizing the temperature profile of the reflow oven and performing regular calibration of the oven.

4) Monitoring After Improvement

Data after corrective action was collected by recording the number of defects in PCBA production for five weeks, starting from the 4th week of January 2025 to the 4th week of February 2025.

Table 5. Number of failed PCBA products After Action.

Production Time	Good (pcs)	Reject (pcs)	Total (pcs)	% Reject
4th week of January 2025	8070	280	8350	3,35%
1st week of February 2025	5300	150	5450	2,75%
2nd week of February 2025	3630	70	3700	1,89%
3rd week of February 2025	4410	90	4500	2%
4th week of February 2025	5200	100	5300	1,8%
Total	26610	690	27300	2,52%

From the data after the corrective action was taken, it was found that the total production failures carried out for five weeks, the highest percentage was seen in the 4th week of January 2025 which amounted to 3.35% and the lowest percentage in the 4th week of February 2025 which amounted to 1,8%. It can be seen that the average percentage of production failures per week before improvement is 2.52%. This indicates a potential decrease in problems in the production process with a decreasing percentage number.

Table 6. Number of Defective units in production After Action.

Production Time	Total Units (pcs)	Total Defective Boards (pcs)	Type of Defect					Total Defective Components (pcs)
			Bridging	Tombstoning	Shifting	Insufficient Solder	Solder Balls	
4th Week of Jan 2025	8350	280	90	80	58	48	29	305
1st Week of Feb 2025	5450	150	72	54	36	28	16	206
2nd Week of Feb 2025	3700	70	45	30	22	16	11	124
3rd Week of Feb 2025	4500	90	58	42	38	24	16	178
4th Week of Feb 2025	5300	100	65	48	32	29	22	196
Total	27300	690	330	254	186	145	94	1009

Based on the data in Table 6 after corrective action is taken, it shows component defects detected in the AOI (Automated Optical Inspection) machine process per week for PCB Model X, with an observation period from week 4th of January 2025 to week 4th of February 2025. The total PCBA defects detected were 690 pcs from a total output of 27300 pcs, so the total component defects detected by the AOI machine decreased from week to week with a total component defect of 1,009 pcs for five weeks after repair. The most dominant defect type is still dominated by bridging with 330 pcs, followed by tombstoning with 254 pcs. This decrease in the number of defects shows that the corrective actions that have been taken have a positive impact on improving the quality of PCBA production.

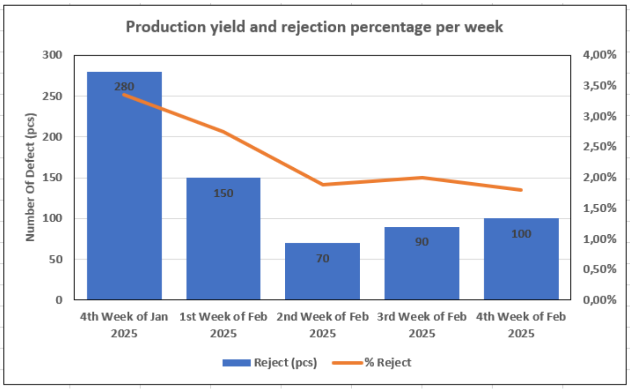

Figure 5. Production yield and rejection percentage per week After Action.

Based on the Pareto Diagram in Figure 5 after corrective action is taken, it shows the number of rejected product pcs and the percentage of rejects in the production process with a span of five weeks from Week 4th January 2025 to Week 4th February 2025. There was a significant decrease in the number of defects from 280 pcs in the 4th week of January 2025 to 70 pcs in the 2nd week of February 2025. The reject percentage also decreased from about 3.6% to 1.7%. Although there were slight fluctuations in the 3rd and 4th weeks of February 2025, the number of defects remained lower than before the improvement. This shows that the corrective actions taken were successful in reducing the defect rate in the production process.

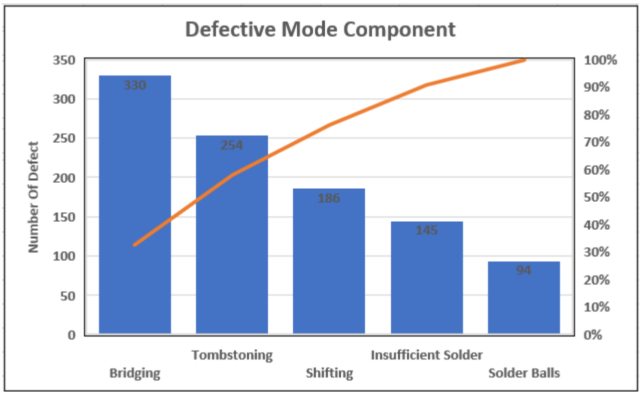

Figure 6. Defective Mode Component After Action.

Based on the Pareto Diagram in Figure 6 shows the number of defects based on the type or mode of defects in the PCB production process after corrective action. Based on the data, the number of defects has decreased significantly compared to the conditions before improvement. The bridging defect is still the highest with 330 pcs, followed by tombstoning with 254 pcs. The cumulative curve shows that the two main types of defects, namely bridging and tombstoning, contribute around 80% of the total defects. This indicates that despite improvements, these two defects remain the main focus for further quality control to reduce the overall number of rejects.

IV. Conclusion

Research on PCB Defect Analysis in Reflow Soldering Process using PFMEA method resulted in three main conclusions. First, identifying the causes of the main defects using PFMEA method, the main defects that occur in the reflow soldering process include bridging, and tombstoning. The main cause of these defects is related to the non-optimal reflow temperature profile parameter factor. Second, risk prioritization based on RPN value from PFMEA analysis results, bridging soldering defect has the highest Risk Priority Number (RPN) value and tombstoning defect has the lowest Risk Priority Number (RPN) value which indicates that the factor requires special attention in process improvement efforts. Third, by applying the PFMEA method, this study successfully achieved the objectives of identifying, analyzing, and providing recommendations for improvements to the causes of defects in the reflow soldering process. Implementation of the proposed improvements can significantly reduce the defect rate and improve the quality of PCB products.

References

[1] N. Karnik, U. Bora, K. Bhadri, P. Kadambi, and P. Dhatrak, “A comprehensive study on current and future trends towards the characteristics and enablers of industry 4.0,” *J Ind Inf Integr*, vol. 27, p. 100294, May 2022, doi: 10.1016/j.jii.2021.100294.

[2] T.-N. Tsai, “Thermal parameters optimization of a reflow soldering profile in printed circuit board assembly: A comparative study,” *Appl Soft Comput*, vol. 12, no. 8, pp. 2601–2613, Aug. 2012, doi: 10.1016/j.asoc.2012.03.066.

[3] R. Yasra, “ANALISIS TERJADINYA REJECT PCB LED PADA SMT LINE DENGAN MENGGUNAKAN METODE ROOT CAUSE ANALYSIS FISHBONE DAN FMEA DI PT VJB,” *Jurnal Teknik Ibnu Sina (JT-IBSI)*, vol. 8, no. 01, pp. 65–78, Jun. 2023, doi: 10.36352/jt-ibsi.v8i01.637.

[4] E. Sugito, W. Nugraha, and Z. A. Palirie, “STRATEGI PEMASARAN PRODUK FASHION DENGAN METODE ANALISIS SWOT (STUDI KASUS FORTESIX CLOTHING),” *Jurnal Teknik Ibnu Sina (JT-IBSI)*, vol. 8, no. 01, pp. 1–11, Jun. 2023, doi: 10.36352/jt-ibsi.v8i01.587.

[5] A. Nur Fajrin, D. Darlis SSi, and R. S. Ardianto Priramadhi, “ALAT REFLOW SOLDERING DENGAN PENGATURAN SUHU REFLOW SOLDERING TOOL WITH TEMPERATURE CONTROL,” Bandung, Aug. 2020. Accessed: May 25, 2025. [Online]. Available: https://openlibrarypublications.telkomuniversity.ac.id/index.php/appliedscience/article/view/13390/12954

[6] kicthermal, “Common Reflow Oven Faults and Their Impact on Electronics Manufacturing.” Accessed: May 25, 2025. [Online]. Available: https://kicthermal-com.translate.goog/article-paper/common-reflow-oven-faults-and-their-impact-on-electronics-manufacturing/?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=sge#:~:text=Oven%20reflow%20mengandalkan%20pemanas%20untuk,lain%20menerima%20terlalu%20sedikit%20panas.

[7] I. Bozsóki, A. Géczy, and B. Illés, “Overview of Different Approaches in Numerical Modelling of Reflow Soldering Applications,” *Energies (Basel)*, vol. 16, no. 16, p. 5856, Aug. 2023, doi: 10.3390/en16165856.

[8] Ning-Cheng Lee, *Reflow Soldering Processes and Troubleshooting: SMT, BGA, CSP and Flip Chip Technologies*. Amerika Serikat, 2002. Accessed: Dec. 17, 2024. [Online]. Available: http://160592857366.free.fr/joe/ebooks/Electronics%20and%20Electrical%20Engineering%20Collection/LEE,%20N.-C.%20(2001).%20Reflow%20Soldering%20Processes%20and%20Troubleshooting%20-%20SMT,%20BGA,%20CSP%20and%20Flip%20Chip%20Techn/Reflow_Soldering_Processes_Troubleshooting.pdf

[9] S.-S. Deng, S.-J. Hwang, and H.-H. Lee, “Temperature prediction for system in package assembly during the reflow soldering process,” *Int J Heat Mass Transf*, vol. 98, pp. 1–9, Jul. 2016, doi: 10.1016/j.ijheatmasstransfer.2016.03.008.

[10] Umar Waseem, “Solder Reflow: Panduan Lengkap tentang Proses dan Tekniknya,” wevolver. Accessed: Nov. 16, 2024. [Online]. Available: https://www.wevolver.com/article/reflow-soldering

[11] Ed Briggs and Ph. D. , P. Ronald C. Lasky, “Best Practices Reflow Profiling for Lead-Free SMT Assembly,” Jun. 2016, Accessed: Dec. 17, 2024. [Online]. Available: https://kicthermal.com/article-paper/best-practices-reflow-profiling-for-lead-free-smt-assembly/

[12] P. D. F. Khalishah Livia, “112045-ID-evaluasi-peningkatan-kinerja-produksi-me”, Accessed: May 25, 2025. [Online]. Available: https://media.neliti.com/media/publications/112045-ID-evaluasi-peningkatan-kinerja-produksi-me.pdf

[13] Robin E. McDermott, Raymond J. Mikulak, and Michael R. Beauregard, *THE BASIC OF FMEA 2nd Edition* , 2nd ed. 2009. Accessed: Dec. 17, 2024. [Online]. Available: https://books.google.co.id/books?hl=en&lr=&id=6_gvEQAAQBAJ&oi=fnd&pg=PP7&dq=fmea+mcdermott+2009&ots=8m1z8BdBbx&sig=0bwt80-paRLK2eIBcXd_uR1OyiQ&redir_esc=y#v=onepage&q=fmea%20mcdermott%202009&f=false

[14] A. C. Kutlu and M. Ekmekçioğlu, “Fuzzy failure modes and effects analysis by using fuzzy TOPSIS-based fuzzy AHP,” *Expert Syst Appl*, vol. 39, no. 1, pp. 61–67, Jan. 2012, doi: 10.1016/j.eswa.2011.06.044.

[15] Salsabila Mayori Cahyaningrum and Sriyanto, “IDENTIFIKASI PENYEBAB CACAT PRODUKSI KERTAS TEST LINERMENGGUNAKAN METODE FAILURE MODE & EFFECT ANALYSIS(FMEA),” vol. 8, no. 2, pp. 1–6, 2019, Accessed: Dec. 17, 2024. [Online]. Available: https://ejournal3.undip.ac.id/index.php/ieoj/article/view/23759/21614

[16] M. baghbani, S. Iranzadeh, and M. Bagherzadeh khajeh, “Investigating the relationship between RPN parameters in fuzzy PFMEA and OEE in a sugar factory,” *J Loss Prev Process Ind*, vol. 60, pp. 221–232, Jul. 2019, doi: 10.1016/j.jlp.2019.05.003.

[17] D. C. Montgomery, *Introduction to Statistical Quality Control*, 8th ed. 2019. Accessed: Jun. 16, 2025. [Online]. Available: https://books.google.co.id/books?hl=en&lr=&id=oh7zDwAAQBAJ&oi=fnd&pg=PA2&dq=introduction+to+statistical+quality+co

ntrol+8th+ed&ots=DsBs9-Gc1D&sig=g33exCmtTvAoe5vkZY-
jD2mWGMo&redir_esc=y#v=onepage&q&f=false

Table 7. Process Failure Mode and Effect Analysis (PFMEA).

Process Failure Mode and Effect Analysis (PFMEA)

Process/Product Name: PCB Defects in Reflow soldering process
Responsible: Tanto Wijaya
Prepared By: Tanto Wijaya
FMEA Date (Orig.): Jan 31th, 2025 (Rev.): Jan 31th, 2025

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN	Action Recommended	Resp.	Actions Taken	SEVERITY (1 - 10)	OCCURRENCE (1 - 10)	DETECTION (1 - 10)	RPN
What is the process step or feature under investigation?	In what ways could the step or feature go wrong?	What is the impact on the customer if this failure is not prevented or corrected?		What causes the step or feature to go wrong? (how could it occur?)		What controls exist that either prevent or detect the failure?			What are the recommended actions for reducing the occurrence of the cause or improving detection?	Who is responsible for making sure the actions are completed?	What actions were completed (and when) with respect to the RPN?				
Reflow Soldering	Solder Bridging	Excessive solder paste, Short circuit between component pins	8	Overprinted solder paste, Sub-optimal stencil design	7	Machine Automated Optical Inspection (AOI), Visual inspection using Microscope	4	224	Calibrate solder paste printing and optimize stencil design	Technician	Even distribution of solder paste, Optimization of distance between path and pad	5	6	7	210
Reflow Soldering	Tombstoning	Uneven soldering, Component raised at one end	8	Unstable temperature profile, Uneven solder paste	6	Machine Automated Optical Inspection (AOI), Visual inspection using Microscope	4	192	Stabilize reflow temperature profile with predefined standard solder paste and optimize stencil design	Technician	Optimized temperature profile with predefined standards, Optimized distance between trace and pad.	5	6	6	180

Attachment

A. Attachment – Reflow Oven Soldering Machine

Figure 7. Reflow Oven Soldering Machine

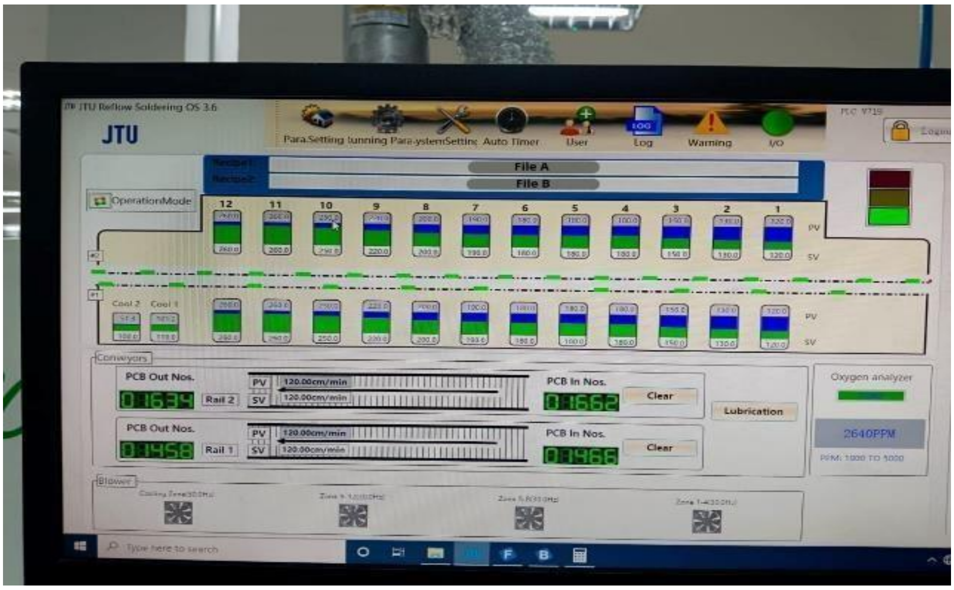

Figure 8. Display Reflow Temperature

Figure 9. Display Reflow Temperature Profile

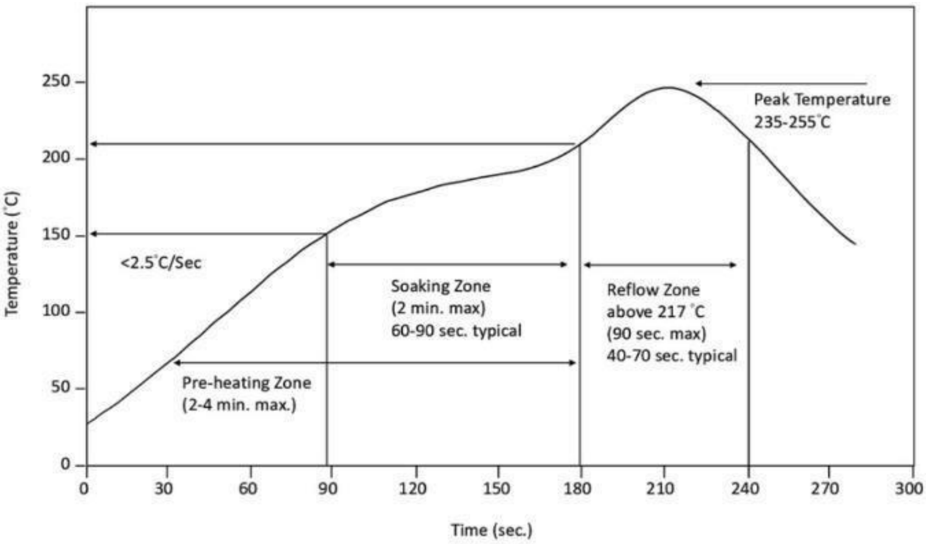

Figure 10. Reflow Profile Graph

B. Attachment – AOI Machine

Figure 11. Machine AOI (MV-6DL-MIRTEC)

Specifications

Model			MV-6 OMNI		
Type Code			MV-6_M_OMNI_S_SL	MV-6_M_OMNI_S_DL	MV-6_M_OMNI_T_SL
Max. PCB Size Range					
In-Line AOI			50 x 50 - 510 x 460 mm	50 x 50 - 510 x 580 mm (Single) 50 x 50 - 510 x 300 mm (Dual)	50 x 50 - 330 x 460 mm 50 x 50 - 510 x 460 mm
OMNI-VISION® 3D / 2D Inspection Technology					
3D Inspection Technology			Digital 12 Projection Moiré Technology		
Height Accuracy			±3 μm		
3D / 2D Maximum Inspection Speed					
25 Megapixel Camera	CoaXPress	7.7 μm	1,480mm²/ Sec		
15 Megapixel Camera	CoaXPress	10 μm	1,890mm²/ Sec		
		15 μm	4,260mm²/ Sec		
2D Maximum Inspection Speed					
25 Megapixel Camera	CoaXPress	7.7 μm	4,593mm²/ Sec		
15 Megapixel Camera	CoaXPress	10 μm	5,080mm²/ Sec		
		15 μm	10,718mm²/ Sec		
System Specification					
Lighting System			8 Phase Coaxial Color Lighting System		
Side Camera System		Option	18/10 Megapixel Digital Color Side Camera (4ea)		
Software		Standard	Built-in SPC, Built-in Repair		
		Option	RMS, RRS, IRS, OLTT, RDS, Remote SPC, ePM-AOI		
PCB Top Side Clearance			45mm		
PCB Bottom Side Clearance			50mm		
PCB Thickness			0.5mm - 5mm		
Maximum PCB Weight			4kg		
Minimum Measurement Size	25M CXP Camera	7.7 μm	03015 Chip (mm) / 0.3 Pitch (mm)		
	15M CXP Camera	10 μm	03015 Chip (mm) / 0.3 Pitch (mm)		
		15 μm	0603 Chip (mm) / 0201 Chip (inch) / 0.4 Pitch (mm)		
Robot Positioning System		X/Y Axis	Servo Motor System		
Power Requirements			Single Phase(s) 200-240V 50-60Hz, 1.1kw		
Air Requirements			5 Kgf / cm² (0.5 MPa), 5 LPM		
Dimension and Weight					
Dimension (mm)	Machine		1,080(W) x 1,470(D) x 1,610(H)		
	Width (Machine & Conveyor)		1,110	1,110	1,270 / 1,450 / 1,630
Weight			Approx. 950 kg	Approx. 1,000 kg	Approx. 950 kg

※ We will not be responsible for any problems caused by using unverified BARCODE READER. Contact our HQ for the list of allowed BARCODE READER models to use.

Figure 12. Specifications Machine AOI MIRTEC

C. Attachment – AOI Machine

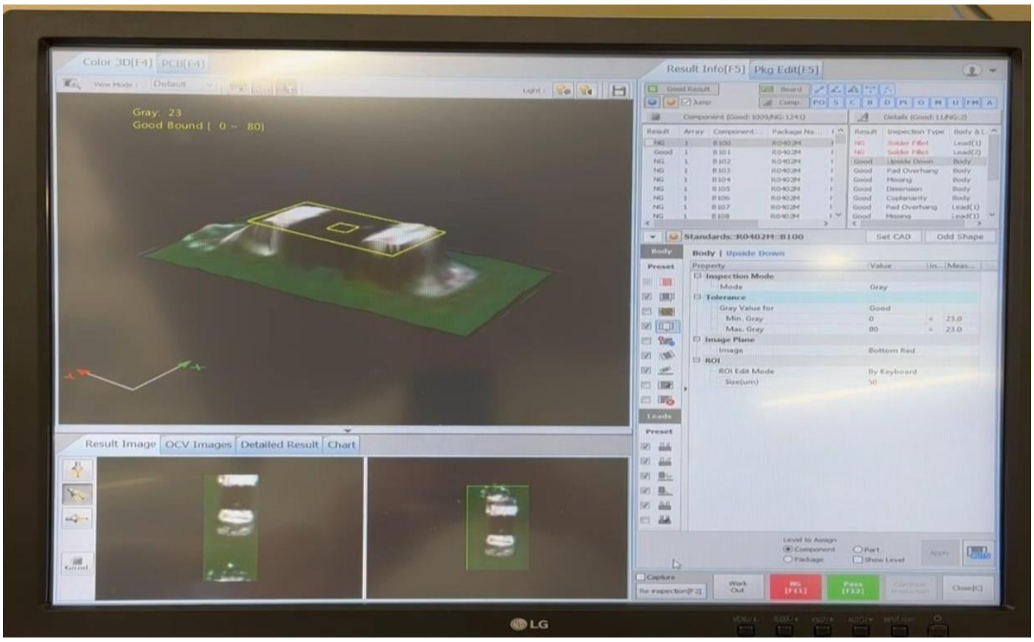

Figure 13. Defective display of SPI machine components

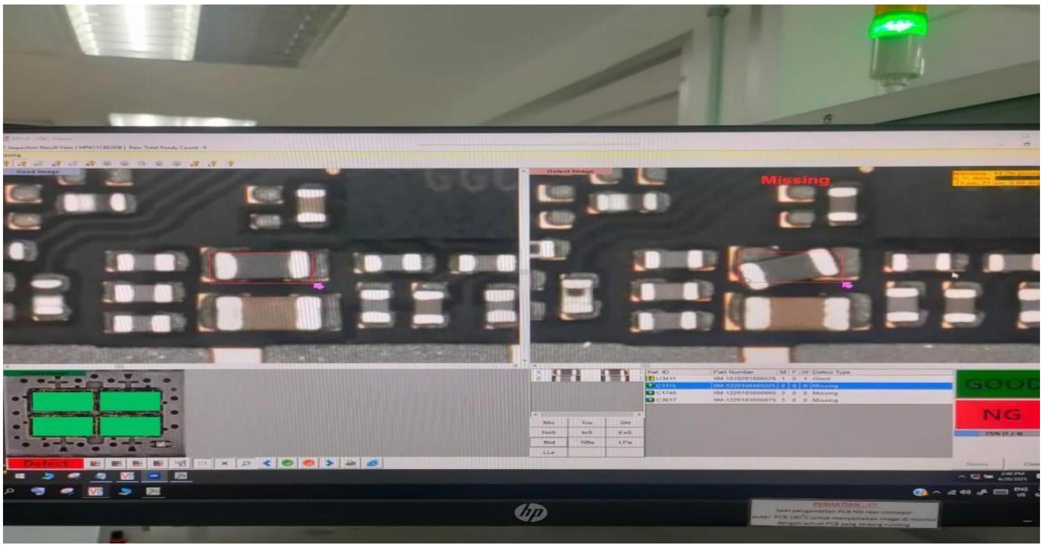

Figure 14. Defective display of SPI machine components

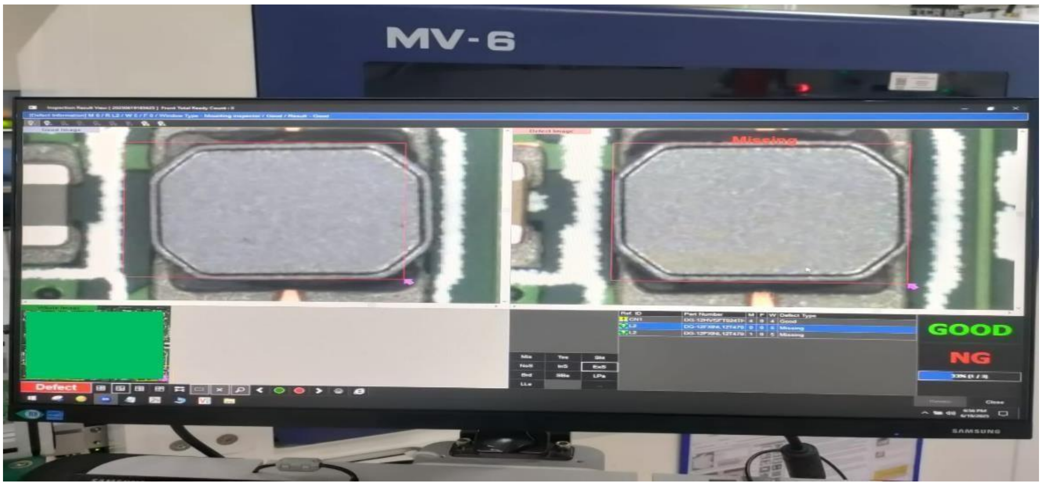

Figure 15. Defective display of SPI machine components

Figure 16. Defective display of SPI machine components

D. Attachment – Description PFMEA

Severity Scale

Adapt as appropriate

Effect	Criteria: Severity of Effect	Ranking
Hazardous - Without Warning	May expose client to loss, harm or major disruption - failure will occur **without** warning	10
Hazardous - With Warning	May expose client to loss, harm or major disruption - failure will occur **with** warning	9
Very High	Major disruption of service involving client interaction, resulting in either associate re-work or inconvenience to client	8
High	Minor disruption of service involving client interaction and resulting in either associate re-work or inconvenience to clients	7
Moderate	Major disruption of service not involving client interaction and resulting in either associate re-work or inconvenience to clients	6
Low	Minor disruption of service not involving client interaction and resulting in either associate re-work or inconvenience to clients	5
Very Low	Minor disruption of service involving client interaction that does not result in either associate re-work or inconvenience to clients	4
Minor	Minor disruption of service not involving client interaction and does not result in either associate re-work or inconvenience to clients	3
Very Minor	No disruption of service noticed by the client in any capacity and does not result in either associate re-work or inconvenience to clients	2
None	No Effect	1

Occurrence Scale

Probability of Failure	Time Period	Per Item Failure Rates	Ranking
Very High: Failure is almost inevitable	More than once per day	>= 1 in 2	10
	Once every 3-4 days	1 in 3	9
High: Generally associated with processes similar to previous processes that have often failed	Once every week	1 in 8	8
	Once every month	1in 20	7
Moderate: Generally associated with processes similar to previous processes which have experienced occasional failures, but not in major proportions	Once every 3 months	1 in 80	6
	Once every 6 months	1 in 400	5
	Once a year	1 in 800	4
Low: Isolated failures associated with similar processes	Once every 1 - 3 years	1 in 1,500	3
Very Low: Only isolated failures associated with almost identical processes	Once every 3 - 6 years	1 in 3,000	2
Remote: Failure is unlikely. No failures associated with almost identical processes	Once Every 7+ Years	1 in 6000	1

Detection Scale

Detection	Criteria: Likelihood the existence of a defect will be detected by process controls before next or subsequent process, -OR- before exposure to a client	Ranking
Almost Impossible	No known controls available to detect failure mode	10
Very Remote	Very remote likelihood current controls will detect failure mode	9
Remote	Remote likelihood current controls will detect failure mode	8
Very Low	Very low likelihood current controls will detect failure mode	7
Low	Low likelihood current controls will detect failure mode	6
Moderate	Moderate likelihood current controls will detect failure mode	5
Moderately High	Moderately high likelihood current controls will detect failure mode	4
High	High likelihood current controls will detect failure mode	3
Very High	Very high likelihood current controls will detect failure mode	2
Almost Certain	Current controls almost certain to detect the failure mode. Reliable detection controls are known with similar processes.	1

Figure 17. Description of PFMEA Table Assessment

Biodata

	Name TTL Religion Address E-mail Educational background Elementary School Junior High School Senior High School	: Tanto Wijaya : Batam, 13 Januari 2002 : Islam : Perum Persero Blok B No 03 RT/RW:001/010, Kelurahan Tanjung Sengkuang, Kecamatan Batu Ampar Batam : tantowijaya013@gmail.com : SD N 001 Batu Ampar Batam : SMP N 29 Batam : SMK S Multistudy High School Batam