Utilizing Automated Manufacturing Execution System (MES) to Reduce Quality Issues due to Wrong Reel Labeling

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ABSTRACT

Test Internal Quality indicator as of Aug-Q2FY25 is high at 20 occurrences vs its FY25 target of 27 occurrences. Test Internal Quality are quality incidents found during the Manual Visual Inspection (MVI) process prior packing. The team simulated and forecasted the FY25 end-result with 48 occurrences based on the monthly run-rate. And, potential Rework Cost of USD 2,000 per quarter.

The team used and applied Lean Six Sigma tools and methodologies through the PDCA (Plan-Do-Check-Act) approach. These tools such as Gemba Walk, Pareto Diagram, Bar Graphs (for trends), Process Mapping, the Ishikawa (Fishbone) Diagram, Fault-Tree and Why-why Analysis guided us in our prioritization in selecting the top defects, determining potential causes and finding the true root causes to eventually implement improvements resulted to achieve our target.

Our root cause analysis drives us to identify the top contributor in Manual Visual Inspection (MVI) process which is the "Wrong Reel Label" that contributed the 23% of the overall defect occurrence. 8 potential root causes were initially identified and thru validation, the Team narrow down these to 3 true root cause which are a) "Operator did not follow standard procedure wherein to print the label before performing the MVI", b) "Manual input of vial lot quantity in label application" and c) "Operator did not follow standard procedure wherein to use traveler as reference to check information details in label printing.". To be able to minimize if not eliminate these root causes, the Team implemented the main countermeasures of a) "Enhancement of Manufacturing Execution System (MES) by Barcoding the reel label to transact the MVI result", and the b) "Enhancement of control in MES to "Reject" condition with less/more than the standard reel quantity".

The combination of enhancements in the MES resulted the mitigation on further occurrence by 43% less on the overall defect occurrence in Manual Visual Inspection process (from simulated 48 occurrences to 27 occurrence) at the end of FY25. Zero defect re-occurrence of "Wrong Reel Label" defect within 4 months after the full implementation across all business units in Dec-Q3FY25. These also resulted in the Cost Avoidance of USD 2,000 per quarter due to rework cost.

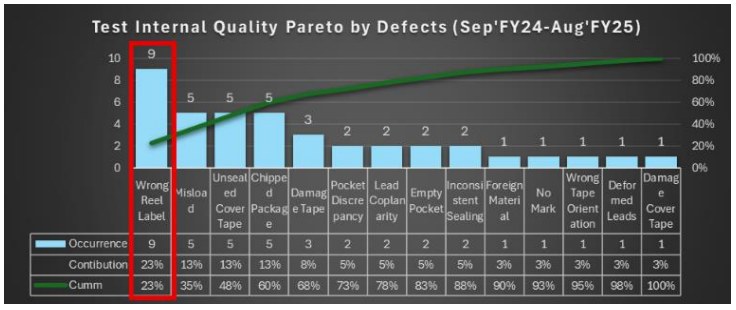
1. 0 INTRODUCTION

1.1 Project Background

Allegro MicroSystems Phils., Inc. (AMPI) aims to deliver high quality products aside from the cost and on-time delivery. To attain this, AMPI, specifically in Test Operations, set limits and measures the leading indicators to guide us on its status which eventually drives us to initiate improvements.

The Team focuses on Test Internal Quality indicator which is high at 20 occurrences vs its FY25 target of 27 occurrences as of Aug-Q2FY25.

Using pareto diagram, the team used the Test Internal Quality data from the last 12 months (Sep'FY24 ~ Aug'FY25) to have more data population regarding defect contribution. With this, the team found out that "Wrong Reel Label" issue contributes 23% on the overall Test Internal Quality, averaging 2 occurrence per quarter. (see Figure 1)



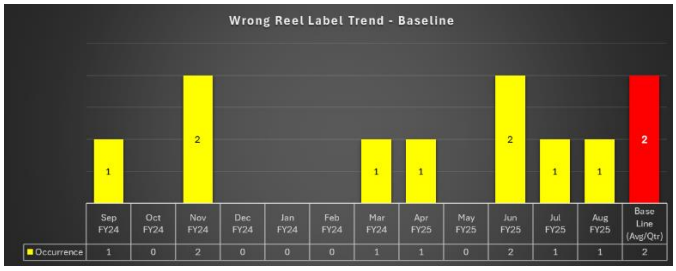


Fig. 1. "Wrong Reel Label" issue contributed 23% on the overall Test Internal Quality occurrence, averaging 2 occurrence per quarter from Sep'FY24 to Aug'FY25.

To further understand "Wrong Reel Label" issue, we reviewed its operational definition thru a specification for visual defects and criteria defining the issue as "Any information in label that does not tally on the reference documents."

The Team also identified 3 Wrong Reel Label scenarios: a) "No declaration of vial lot" (see Figure 2a, b) "Wrong declaration of Vial Quantity" (see Figure 2b) and c) "Wrong part no./lot no. declared" (see Figure 2c)

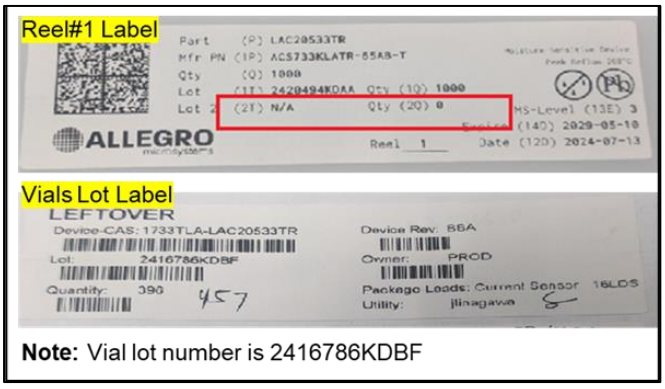


Fig. 2a. Wrong Reel Label scenario a) "No declaration of vials".

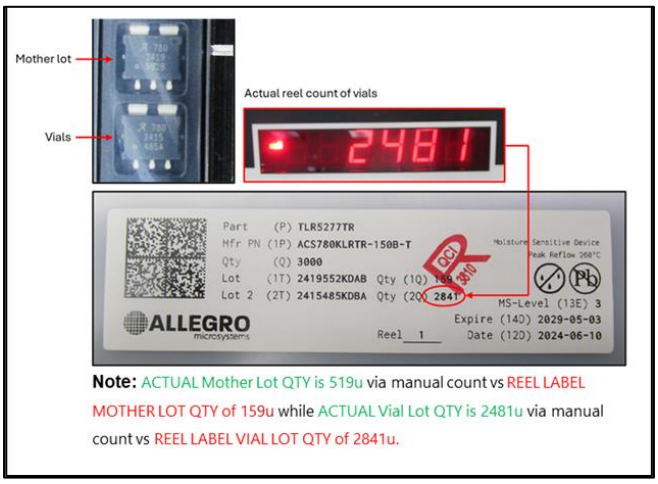


Fig. 2b. Wrong Reel Label scenario b) "Wrong declaration of Vials Quantity".

Fig. 2c. Wrong Reel Label scenario c) "Wrong part no./lot no. declared".

1.2 Objective

The Team aimed to reduce Wrong Reel Label issue occurrence from an average of 2 per quarter to 1 per quarter, or 50% reduction by the end of Dec-Q3FY25.

1.3 Scope and Limitation

The scope of the project will cover Tape and Reel process of all packages. And this does not include label issues due to misprocess.

2. 0 REVIEW OF RELATED WORK

This section is "Not Applicable" for this project

3.0 METHODOLOGY

The Team recognized and acknowledged that to be able to understand the "Wrong Reel Label" issue, we need to check and observe the current situation on the actual process, actual location in line by doing the Gemba Walk. We interviewed Operators, Utility Operators and Supervisors regarding the occurrence, and took note of their own observations, suggestions, and insights regarding this issue. We also reviewed the current control from FMEA and Control Plan and checked if it's still implemented in line. We observed that

the issue comes from the Tape and Reel process across all packages, thus we used Process Mapping to further identify its cause. Its sub-process "Label Generation and Reel Validation" shows the gap we are looking for. (see Figure 3)

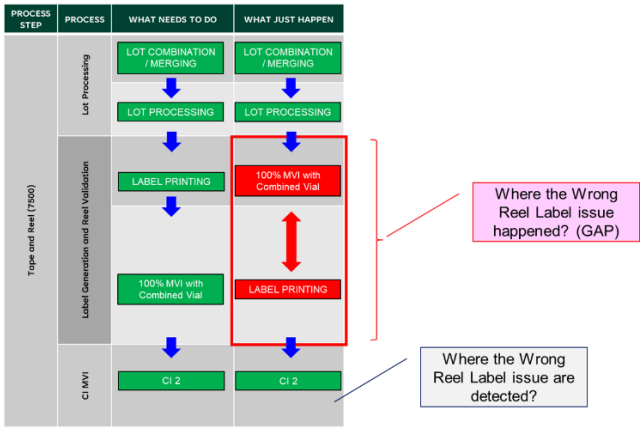


Fig. 3. Process Mapping tool shows that the occurrence happened during the "Label Generation and Reel Validation" sub-process of the Tape and Reel process.

With this information, we re-group and sit-down for a brain-storming session and used the Ishikawa (Fishbone) Diagram to discuss further what we had observed during our Gemba Walk. Based on the brainstorming, we identified a total of 8 potential root causes mostly due to "Man" within the 3 Wrong Reel Label scenarios. For "No declaration of vials" scenario we found 3 (Did not follow standard procedure wherein to print the label before performing the MVI, Insufficient no. of printers and Printer location far from the TR area), for "Wrong declaration of vials quantity" scenario we found 4 (Manual input of vial quantity in label application – 2, Did not follow standard procedure wherein to print the label before performing the MVI and Insufficient no. of printers) and for "Wrong part number declared" we found 1 (Operator did not follow standard procedure). (see Figure 4)

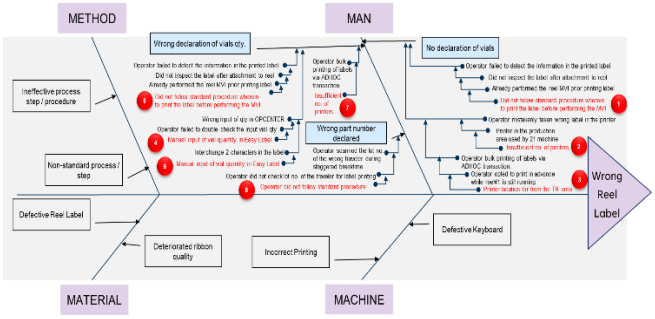


Fig. 4. 8 potential root causes were identified using the Ishikawa (Fishbone) Diagram.

After the Team identified the 8 potential root causes, we apply the Fault-Tree Analysis and do validation for each of the potential root causes. From 8 potential root causes, based on the result of the validation, it narrowed down to 5 true root causes and was group into 3 which are a) "Operator did not follow standard procedure wherein to print the label before performing the MVI", b) "Manual input of vial quantity in label application" and c) "Operator did not follow standard procedure wherein to use traveler as reference to check information details in label printing.". Discussion of its validation results and its countermeasure will be on the succeeding paragraphs. (see Figure 5)

Defect	Defect Signature	Potential Root Cause	Method of Validation	Validation Result	Conclusion
Wrong Reel Label	A. No Declaration of Vials	Operator did not follow standard procedure wherein to print the label before performing the MVI	Interview Operator the sequence of TR process (Setup to Label Printing)	3 out of 5 Operators do the MVI of reel prior printing of label	TRUE ROOT CAUSE
		Insufficient no. of printers (no printer management)	Check in actual	No. of printers not relative to the issue, the problem is the advance or bulk printing of label.	Not Possible
		Printer location far from the TR area	Check in actual	No. of printers not relative to the issue, the problem is the advance or bulk printing of label.	Not Possible
	B. Wrong declaration of vials qty.	Manual input of vial quantity in Label Application	Check in actual	Label Application default is to input vial quantity for lot with merged lot. Also the system accepts anything inputted even discrepant to the quantity of vial. Therefore not relative to the issue.	TRUE ROOT CAUSE
		Manual input of vial quantity in Label Application	Check in actual	Label Application default is to input vial quantity for lot with merged lot. Also the system accepts anything inputted even discrepant to the quantity of vial. Therefore not relative to the issue.	TRUE ROOT CAUSE
		Operator did not follow standard procedure wherein to print the label before performing the MVI	Check in actual	3 out of 5 Operators do the MVI of reel prior printing of label	TRUE ROOT CAUSE
		Insufficient no. of printers (no printer management)	Check in actual	No. of printers not relative to the issue, the problem is the advance or bulk printing of label.	Not possible
	C. Wrong part number declared	Operator did not follow standard procedure	Check in actual	Operator scanned the lot no. of the wrong traveler and did not check the actual label	TRUE ROOT CAUSE

Fig. 5. 3 true root causes identified after the validation. a) "Operator did not follow standard procedure wherein to print the label before performing the MVI" (yellow highlight), b) "Manual input of vial quantity in Label Application" (blue highlight) and c) "Operator did not follow standard procedure wherein to use traveler as reference to check information details in label printing." (green highlight).

3.1 Operator did not follow standard procedure wherein to print the label before performing the MVI

To ensure that the implemented procedure will be mistake proofed, an enhancement of MES by Barcoding the reel label to transact the MVI result is added as countermeasure. (see Figure 6)

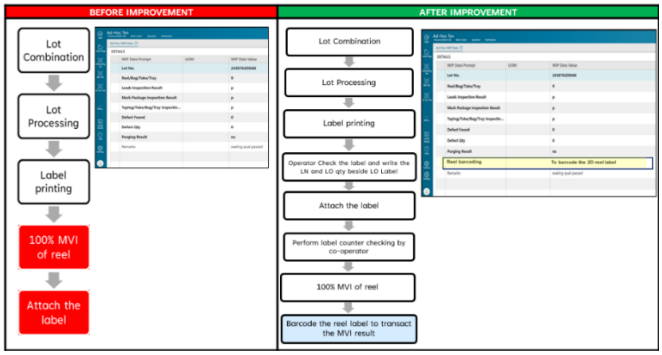


Fig. 6. To control the interchanging of process through Barcoding the reel label to transact the MVI result, an enhancement of MES by Barcoding the reel label to transact the MVI result is added as countermeasure.

3.2 Manual input of vial quantity in Label Application

This root cause was potentially found in Wrong Reel Label scenario due to Wrong declaration of vials quantity and was validated as true root cause thru 'Observing, Simulating and Checking in actual', as observed and the result of simulation, it was found out that 'Label Application default is to input vial quantity for lot with merged lot and also the system accepts anything inputted even discrepant to the quantity of vial'. The Team implemented an enhancement of control in MES to "Reject" condition with less/more than the standard reel quantity. (see Figure 7)

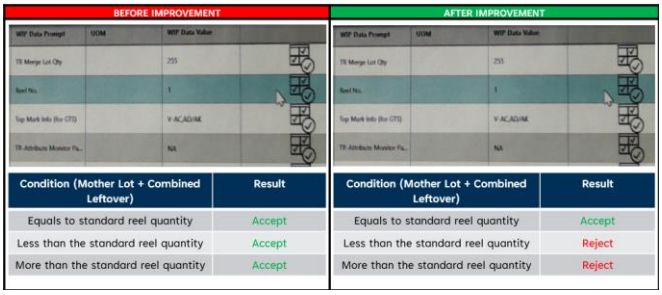


Fig. 7. An enhancement of control in MES to "Reject" condition with less/more than the standard reel quantity was implemented as countermeasure to 'wrong declaration of vials quantity.'

3.3 Operator did not follow standard procedure wherein to use traveler as reference to check information details in label printing.

This root cause was potentially found in Wrong Reel Label scenario due to Wrong part number declared and was validated as true root cause thru 'Observing, Simulating and Checking in actual', as observed and the result of simulation, it was found out that the 'Operator scanned the lot no. of the wrong traveler and did not check the actual label'. The Team implemented a countermeasure like the mistake proofed action in sub-section 3.1, an enhancement of MES by Barcoding the reel label to transact the MVI result is added as countermeasure. (see Figure 6)

4.0 RESULTS AND DISCUSSION

The Team aimed to reduce Wrong Reel Label issue occurrence from baseline (Sep'FY24~Aug'FY25 data) average of 2 per quarter to 1 per quarter, or 50% reduction by the end of Dec-Q3FY25. After the lean event conducted last Sep'FY25~Oct'FY25 with all the countermeasures implemented, the target reduction was achieved in Dec'FY25 and zeroed-out and sustained until Mar-Q4FY25. (see Figure 8).

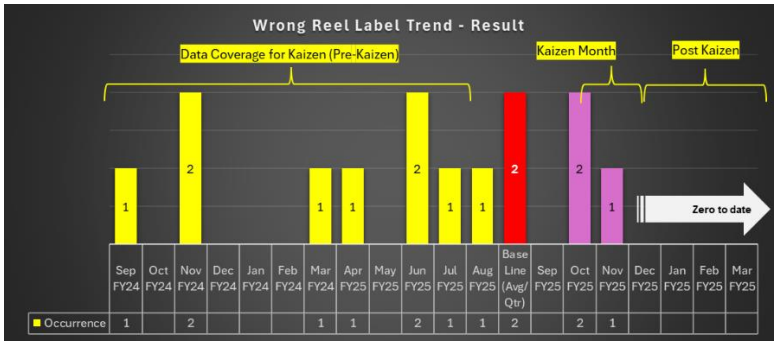


Fig. 8. Target achieved by Dec-Q3FY25 and sustained zero occurrence by the end of Mar-Q4FY25.

The Team also mitigated the potential 48 Test Internal Quality occurrence to 27 occurrences. (see Table 1)

Table 1. Summary of Test Internal Quality ICAR (with FY25 End-Result Forecast.

KPI	FY25 Aug Result	FY25 Target	BEFORE / AFTER FY25 End-Result Forecast		% Improvement
Test Internal Quality	20	27	48	27	43%

Almost USD 2,000 per quarter or USD 8,000 per year worth of cost avoidance due to rework were also realized by completing this project and implementing all the countermeasures. No additional cost acquired for the enhancement in the system. (see Figure 9)

Fiscal Year	Quarter	Month	Failure Date	Work Week	Defect / Reject	Cost of Rework
FY24	Q2	Sep	18-Sep-23	WW38	Wrong Reel Label	$ 5.41
FY24	Q3	Nov	31-Oct-23	WW44	Wrong Reel Label	$ 1,601.24
FY24	Q3	Nov	18-Nov-23	WW47	Wrong Reel Label	$ 1,334.83
FY24	Q4	Mar	11-Mar-24	WW11	Wrong Reel Label	$ 2,140.30
FY25	Q1	Apr	05-Apr-24	WW16	Wrong Reel Label	$ 817.10
FY25	Q1	Jun	10-Jun-24	WW24	Wrong Reel Label	$ 599.27
FY25	Q1	Jun	22-Jun-24	WW26	Wrong Reel Label	$ 517.19
FY25	Q2	Jul	13-Jul-24	WW29	Wrong Reel Label	$ 455.86
FY25	Q2	Aug	11-Aug-24	WW33	Wrong Reel Label	$ 269.85
FY25	Q3	Oct	08-Oct-24	WW41	Wrong Reel Label	$ 70.20
FY25	Q3	Oct	13-Oct-24	WW42	Wrong Reel Label	$ 46.80
FY25	Q3	Nov	11-Nov-24	WW46	Wrong Reel Label	$ 93.60
		Cumulative Cost Avoidance (per year)				$ 7,951.65
		Cumulative Cost Avoidance (per quarter)				$ 1,987.91

Fig. 9. Almost USD 2,000 per quarter or USD 8,000 per year worth of cost avoidance due to rework were realized upon completion of this project.

5.0 CONCLUSION

The occurrence of Wrong Reel Labels was primarily attributed to manual processes, leading to human-related errors. These errors include: a) "Operator did not follow standard procedure wherein to print the label before performing the MVI", b) "Manual input of vial quantity in Label Application" and c) "Operator did not follow standard procedure wherein to use traveler as reference to check information details in label printing.".

By enhancing and maximizing utilization of MES, the team successfully reduced Test Internal Quality occurrences by 43%, resulting in a cost avoidance of approximately USD 2,000 per quarter, or USD 8,000 annually upon project completion.

To ensure the long-term sustainability of these improvements, the Special Instruction and the Improvement Actions will be permanently documented.

6.0 RECOMMENDATIONS

The team strongly recommends implementing Lean Six Sigma tools and methodologies through the PDCA (Plan-Do-Check-Act) approach to address defects in Test Quality ICAR. Utilizing tools such as Gemba Walk, Pareto Diagram, trend analysis via Bar Graphs, Process Mapping, Ishikawa (Fishbone) Diagram, Fault-Tree Analysis, and Why-Why Analysis enables a more systematic and objective root cause analysis. These methodologies help in identifying problems effectively, leading to the implementation of targeted countermeasures and achieving desired quality improvements.

7.0 ACKNOWLEDGMENT

The authors and the team extend their deepest gratitude to the following individuals, whose invaluable insights, shared experiences, and unwavering support played a crucial role in the successful completion of this project:

To our Test Operations Senior Manager Imelda Enriquez, for her leadership and guidance; to our Department Manager of Site Manufacturing Product Engineering Nelson Garcia, for his sponsorship and strategic direction; to our Department Manager of Test Process Engineering Arnold Dungca, for his facilitation and expert advice; and to our dedicated multi-disciplinary team members, Bryan Conti Lead Engineer from Test Process Engineering, Richard Santos Senior Specialist from Technical Learning and Development, Francis Sumagaysay Supervisor from Manufacturing, Allan Apostol Operator from Manufacturing and Anthony Adornado Utility Operator from Manufacturing.

Their contributions, dedication, and expertise have been instrumental in shaping this project and driving its success.

8.0 REFERENCES

This section is "Not Applicable" for this project

9.0 ABOUT THE AUTHORS

Froilan C. Gandoza is a graduate of Bachelor of Science in Electrical Engineering from Technological University of the Philippines, Manila Campus. He has a total of 22 years of experience in Electronics (7), Electronic Refurbish (10) and Semiconductor (5) industry and assigned as a Senior Engineer for Test Operations Quality from Test Process Engineering Department.

Joy C. Esperar holds a Bachelor of Science in Electronics Engineering from Pamantasan ng Lungsod ng Pasig with 15 years of experience in Quality Control and Assurance within the semiconductor industry. She has developed deep expertise in ensuring high standards of product reliability and process efficiency. She currently serves as a Senior Quality Engineer in the Test Quality Management Engineering Department, where she continues to drive excellence and innovation in quality assurance and control.

Moises "GIO" Apigo graduate of Bachelor of Science in Electronics and Communication Engineering in Polytechnic University of the Philippines, Santo Tomas, Batangas with current experience of 25 years in the combine field of Electronics manufacturing related in assembly with companies like Samsung, Aerospace, and lately in the field of Semiconductors. Currently assigned as the Lead Production Business Process Analyst from Test Process Engineering.

10.0 APPENDIX

This section is "Not Applicable" for this project