DIE ATTACH CHANGE IN EPOXY WEIGHT FOR CONSUMPTION REDUCTION

Mark Daniel L. Madrid
Joseph C. Suarez
Rosalinda F. Frayres

Process Engineering - Operations 2 Assembly Department
STMicroelectronics, Inc. 9 Mt. Drive, LISP2, Brgy. La Mesa, Calamba City 4027 Laguna, Philippines
mark-daniel.madrid@st.com, joseph.suarez@st.com, rosalinda.frayres@st.com

ABSTRACT

This paper presents a comprehensive study on the optimization of the Assy Die Attach station at STMicroelectronics, targeting the significant issue of glue overconsumption. Current processes result in a 60% wastage rate, with only 5 grams of the allocated 14 grams of glue being utilized during each 48-hour production cycle. This not only represents a substantial material loss but also a considerable financial challenge, emphasizing the need for improved resource management strategies. The research employs Force Field Analysis to identify and analyze the various factors contributing to excessive glue consumption, including procedural practices, equipment specifications, workforce behavior, and organizational policies. The goal is to uncover critical leverage points for effective intervention and to devise actionable solutions.

The paper details the pursuit of reducing glue waste by 50% by the end of the fourth quarter of 2022 through the implementation of innovative application techniques, refinement of operational processes, and the potential integration of advanced technologies. An in-depth financial analysis will assess the cost benefits of these waste reduction efforts, particularly in light of the high costs associated with glue supplies. The findings are expected to not only mitigate glue wastage at STMicroelectronics but also to set a new standard for cost-efficiency within the semiconductor manufacturing industry. This initiative aligns with the company's commitment to fostering a culture of continuous improvement and innovation, driving the industry towards smarter and more economical production methods.

1. 0 INTRODUCTION

STMicroelectronics is embarking on a project aimed at significantly reducing material waste and associated costs within its manufacturing processes. A particular focus has been placed on the Assy Die Attach station, where epoxy, a critical adhesive used in semiconductor assembly, is currently applied in excess. The project's primary objective is to halve the current epoxy allocation per syringe from 14 grams to 7 grams, aligning with the actual usage patterns observed over a typical 48-hour production cycle.

The introduction of a reduced epoxy weight is a strategic response to the discovery that, within the current operational parameters, a substantial portion of the adhesive expires unused, leading to unnecessary waste. By adjusting the amount of epoxy per syringe to more accurately reflect consumption—where only 5 grams are utilized out of 14 grams provided—the project aims to minimize the volume of expired material. This adjustment is expected to yield a significant cost-saving opportunity, with the potential to cut related expenses by up to 50%.

This initiative is not only a cost-reduction effort but also a step towards sustainable manufacturing practices. By optimizing the use of materials, STMicroelectronics is demonstrating its commitment to environmental stewardship and operational efficiency. The introduction will delve into the rationale behind the project, the anticipated benefits, and the broader implications for sustainability in the manufacturing sector.

1.1. Problem Identification and Selection or Opportunity Identification

1.1.1 Focus Problem Identification

At Material preparation, the 3 main Direct Material (DM) are Housing Caps, Glass Filter, and Epoxy. Team agreed to focus on one of the controllable Direct Materials (DM) which is the Epoxy.

In the material preparation phase of STMicroelectronics' manufacturing process, three primary Direct Materials (DM) are crucial: Housing Caps, Glass Filters, and Epoxy. A recent analysis has revealed inefficiencies in the utilization of these materials, leading to unnecessary waste and increased production costs. To address this issue effectively, a detailed stratification of the materials is essential.

Stratification of Direct Materials.

1. Housing Caps: These components are integral to the assembly, providing the structural integrity and protection for the internal circuitry. Their usage is generally well-regulated, with minimal variance between allocated and used quantities.
2. Glass Filters: Serving a critical function in optical applications, Glass Filters are used with precision. However, the potential for breakage or contamination requires a buffer stock, slightly elevating the wastage levels.
3. Epoxy: As the binding agent in the assembly process, Epoxy's role is pivotal. Nevertheless, the team has identified a significant discrepancy between the amount of Epoxy prepared and the quantity actually consumed in production.

Focus on Epoxy

After careful consideration, the team has agreed to focus on Epoxy as the controllable Direct Material (DM) with the most significant potential for waste reduction. The current practice involves preparing syringes with 14 grams of Epoxy, yet only 5 grams are typically used within the 48-hour expiration period, leading to a 60% wastage rate. By targeting Epoxy, the team aims to implement a more efficient material preparation process that aligns with actual consumption, thereby reducing waste and achieving cost savings

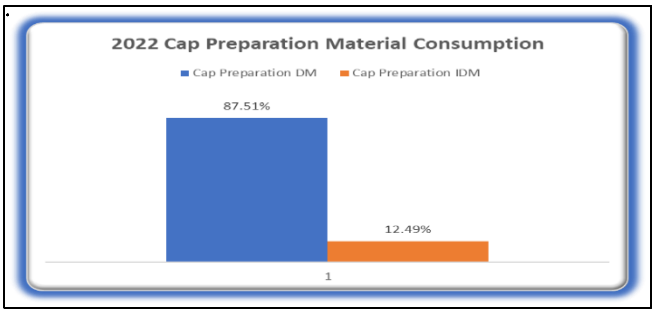


Fig 1. Cap Preparation Material consumption

In the context of production efficiency, the cap preparation process, denoted as DM (Direct Material), has achieved a substantial completion rate of 87.51%. This indicates a high level of effectiveness in the direct handling and preparation of materials. Conversely, the material consumption for IDM (Indirect Material) accounts for 12.49% of the process. This reflects the proportion of resources utilized that are not directly incorporated into the final product but are essential for supporting the manufacturing process.

Epoxy Specifications
1. Technology - Epoxy
2. Appearance - Black
3. Cure - Heat cure
4. Curing Performance - 30min ramp up to 150C and hold 15mins @150C
5. Epoxy Weight - 14grams
6. Work Life - 48hours
7. Shelf Life - 1year

Fig. 2 Loctite Ablestik ABP8420 (14g) currently used in during the processing of units.

1.1.2 Project Relevance to BEM&T CALAMBA 2022 TOP PAGE

This project aligns with the Calamba 2022 Top Page objectives, specifically under Execution and Results, by contributing to two key areas: 1) Year-To-Date (YTD) Unit Cost Trend for Mature Devices: The project embodies the relentless cost reduction efforts in execution by the internal plant (non-proximity). It aims to refine the cost structure through meticulous execution, targeting material overconsumption and optimizing direct material usage, and 2) Environment - Ecological Footprint: this project aims to enhance our ecological footprint by normalizing inputs and outputs relative to production units. Specifically, we target a reduction in waste and cost associated with Cap preparation, an area our team has identified for potential improvement.

2. 0 REVIEW OF RELATED WORK

Refer to 1.0 Introduction.

3.0 METHODOLOGY

For this study, we systematically recorded epoxy usage in die attach machines. Each machine was supplied with two syringes, each containing 14 grams of epoxy, and the usage was tracked for the duration of the epoxy's 48-hour shelf life. Our findings showed that actual epoxy consumption was limited to 5 grams per syringe. To ensure the accuracy of our results, we performed validation checks across multiple machines, which confirmed that a substantial 60% of the epoxy typically remained unconsumed at the time of expiration.

Table 1. Epoxy Consumption Data.

Machine ID	Syringe Lot ID	Syringe mass		Mass
		Before use (g)	After use (g)	difference (g)
Machine01 LEFT	O82HAE6508	23.6	18.376	5.224
Machine01 RIGHT	O82HAE6508	23.7	18.729	4.971
Machine02 LEFT	O82JAA2761	23.751	17.589	6.162
Machine02 RIGHT	O82JAA2761	23.806	18.201	5.605
Machine03 LEFT	O82HAE6508	23.521	18.541	4.98
Machine03 RIGHT	O82HAE6508	23.785	18.327	5.458
Machine05 LEFT	O82JAA2761	23.637	17.525	6.112
Machine05 RIGHT	O82JAA2761	23.724	18.234	5.403
Machine06 LEFT	O82HAF9177	23.872	20.9	2.972
Machine06 RIGHT	O82HAF9177	23.794	20.72	3.074
Machine11 LEFT	O82HAE6508	23.645	18.756	4.889
Machine11 RIGHT	O82HAE6508	23.752	18.227	5.525
Machine12 LEFT	O82HAF9177	23.695	19.198	4.497
Machine12 RIGHT	O82HAF9177	23.725	18.435	5.29
Machine13 LEFT	O82JAA2761	23.685	19.102	4.583
Machine13 RIGHT	O82JAA2761	23.852	18.986	4.956
	Min	23.52	17.53	2.972
	Max	23.87	20.90	6.162
	Average	23.72	18.74	4.98

[a] Matrix shows the epoxy consumed and epoxy remained on the syringe per machine during die attach processing.

3.1. Root Causes and Data Analysis

Force Field Analysis was used to identify the possible Driving Force and Restraining Force and to validate all the restraining forces that needs to be addressed.

Table 2. Force Field Analysis.

(+) DRIVING FORCES	(-) RESTRAINING FORCES
Prevent epoxy waste→	← Would induce other potential issue on glue dispense
Increase knowledge on process qualification→	← Process change would be rejected due to device criticality to change
Increase knowledge on statistical analysis→	← Availability of material
Cost Reduction→	← No budget for the project
Increases knowledge on Report/Technical Writing →	← No training on report writing
Cost Saving→	← Other members would not contribute

Actual Validation of the restraining force confirms the impact of the change. Based on the validation, 1 restraining force was confirmed as True Restraining Force and will proceed to identifying the Alternative Solution.

In line with this Idea our objective is to reduce epoxy consumption usage/cost by 50% at Assy die Attach process by end of Dec 2022.

Table 3. Validation of Potential Restraining Forces

(-) Potential Restraining Forces	Method of Verification	Results of Verification	Conclusion (True Restraining Forces/Not True Restraining Forces)	Controllability
Would induce other potential issue on glue dispense	Dummy Test Run	Need to check on larger volume if can sustain POR parameters and no impact on output responses	Restraining force	Process and SPC Monitoring
Process change would be rejected due to device criticality to change	Team Discussion	Internal OPS2 Team approved the change	Not restraining Force	Process Change Internal Discussion of Evaluation and Results
Cannot complete project without guidance of with knowledge on technical analysis	Team Discussion	Some of the Members and Leader have Statistical Analysis Training	Not restraining Force	Coaching and Brain storming
No motivation as the Process change system is hard	Team Discussion	With regular meeting and support from OPS2 Leaders	Not restraining Force	Coaching and Brain storming
No training on report writing	Team Discussion	Members and Leaders have Technical skills	Not restraining Force	Regular Discussion and Coaching
Other members would not contribute	Team Discussion	Members have roles and contributes to completion of projects	Not restraining Force	Regular Discussion and Coaching

3.2. Solution Formulation (Selection of the Best Alternative Solution)

As for the True Restraining Force, Alternative Solutions were formulated and validated its effectiveness.

Table 4. Alternative Solutions

Identify Alternative Solutions and Validation				
True Restraining Forces	Alternative Solutions	Solution Type	Validation	
			Method	Results
Would induce other potential issue/machine error or incident	Use of epoxy with lower volume available (7g)	Innovative	Use 7g epoxy volume	Dummy test run on B201 set up is OK. Suggest to further validate
	Request epoxy syringe volume (6g)	Innovative	Discussion with supplier	Will incur >2mos of discussion and purchase documentation
	Epoxy transferring from 14g to empty syringe, half of weight	Innovative	Internal Discussion and Test	May cause bubbles on epoxy

4.0 RESULTS AND DISCUSSION

4.1. Statistical Validation Test Run Result

4.1.1 Summary of Best Solutions

The 3 Alternative Solutions are: (1) Use of epoxy syringe - with lower volume available (7g). (2) Request epoxy syringe volume (6g). (3) Epoxy transferring from 14g to empty syringe, half of weight.

The chosen Alternative Solution is #1, the use of 7gram epoxy syringe, was driven by several considerations as follows; 1) Waste Reduction: This option directly addresses the identified issue of a 60% wastage rate by better matching the syringe capacity with actual usage. 2) Cost Efficiency: By halving the volume of epoxy per syringe, we anticipate a significant reduction in material costs. 3) Ease of Implementation: Transitioning to a lower-volume syringe is a straightforward change that can be quickly integrated into the current production process without major disruptions. 4) Environmental Impact: Smaller syringes means less unused material, contributing to STMicroelectronics sustainability goals.

Table 5. Description of Die Attach Epoxy

Item1	Description	FROM	TO	Remarks
1	Die Attach Epoxy			1. Technology - Epoxy (same) 2. Appearance - Black (same) 3. Cure - Heat cure (same) 4. Curing Performance - 30min ramp to 150C and hold 15min @ 150C (same) 5. Epoxy Weight - from 14 grams to 7 grams 6. Work Life - 48 hours (same) 7. Shelf Life - 1 year (same)

4.1.2. Potential Problem Analysis

To anticipate the potential problems that might be encountered during the implementation of the best solution, a PPA was conducted. The adoption of the 7-gram epoxy syringe solution at STMicroelectronics has been strategically orchestrated to preemptively address potential complications. Initially, the shift may lead to dispense-related anomalies due to the altered volume; this is being proactively managed by calibrating the setup to align with the established Process of Record (POR) input parameters and by providing Best Known Method (BKM) training to the technical staff. This measure was put into effect as of week 46 of the work year (WW46). Additionally, the transition from 14g to 7g syringes may precipitate machine errors and Capability Process Index (CPK) discrepancies. The same prophylactic and corrective strategies are being employed to mitigate these risks, with the same timeline for implementation. Another potential concern is the possibility of material shortages resulting from the modified consumption rates. To circumvent this, procurement practices have been adjusted to correspond with the new demand, and vigilant tracking has been established to ensure consistent supply. This particular initiative was successfully concluded in WW47, with verification through the Product Change Management System (PCMS), reference number PTM_CAL_103952. These anticipatory measures are essential to facilitate a seamless transition and to achieve the project's goals of minimizing waste and reducing expenditure.

Table 6. Potential Problem Analysis and Corrective Action

Potential Problem Analysis				
Best Solution	**Potential Problem**	**Potential Cause**	**Preventive Action**	**Containment Action**
Use epoxy syringe with lower volume readily available (7g)	May cause dispense related defect	Brought by changing lower volume	Fix set up to POR Input parameters	Deploy BKM to Technicians
	May cause machine error and CpK failure	Brought by changing 14g to 7g consumption	Fix set up to POR Input parameters	Deploy BKM to Technicians
	May cause material unavailability	Brought by changing 14g to 7g consumption	Align material purchase and usage rate of BPF process to 7g consumption	Material Monitoring

4.1.3. Solution Implementation and Deployment

In adherence to the Plan-Do-Check-Act (PDCA) cycle to guarantee meticulous execution of initiatives, optimal solutions were subsequently enacted, followed by diligent monitoring of performance outcomes. This structured approach facilitated a systematic evaluation and continuous improvement of the process in question.

Table 7. Implementation Plan

PLAN			DO Target Implementation (When)		CHECK	ACT	
Cause (What)	**Solution** (What)	**Step** (How)	**P vs. A**	**RESP** (Who)	**Result Monitoring** (How)	**Learning** (What)	**Status**
May induce glue dispense reject	Set up glue dispense parameters same with POR range	Fix set up to POR input parameters	P A	J. Suarez / M.Ronquillo	Dummy Test Run. Input and Output Responses are within POR range	POR dispense parameters are workable on lower glue weight/volume	Done
		Process Responses Monitoring (Yield / Errors, Cpk)	P A	J. Suarez / M. Ronquillo	Small and Large scale validation	Glue output response is within range , no impact on yield and efficiency	Done
		SPC Monitoring	P A	J. Suarez / M. Ronquillo	Small and Large scale validation	Sustained Output parameters within 1.33 Cpk	Done
May cause material unavailability	Update usage rate and material consumption	Informed IE , Planning and Kitting	P A	K. Chan / Andrea	Epoxy usage rate calculation, Update on Purchase, IDM monitoring	Materials are available since consumed also by other	

4.1.4. Monitoring and Evaluation of Results

4.1.4.1. VALIDATION RESULT: Dispenser Wet Measurement POR vs New Mean

The test results indicate that the introduced 7-gram epoxy is in compliance with the necessary qualification parameters. Achieving a high yield of 99.97%, the die attach process incurs a minimal yield loss of just 0.03%. Notably, the Time Unscheduled Downtime (TUD) averages 9.8%, a figure that is not influenced by the epoxy dispensing process, which infers a sustained dispensing efficiency.

Table 8. Dimensional and Destructive Measurement

Description	Characteristics	Sample Size	Ideal Target	Left Dispenser		Right Dispenser	
				POR Mean	New Mean	POR Mean	New Mean
Wet Measurement	Glue Height Left A	5u	0.045 ± 0.015mm	0.031 mm	0.041 mm	0.031 mm	0.041 mm
	Glue Height Left C	5u	0.045 ± 0.015mm	0.033 mm	0.040 mm	0.033 mm	0.040 mm
	Glue Height Left D	5u	0.045 ± 0.015mm	0.033 mm	0.041 mm	0.033 mm	0.041 mm
	Glue Height Left E	5u	0.045 ± 0.015mm	0.032 mm	0.041 mm	0.032 mm	0.041 mm
	Glue Height Left F	5u	0.045 ± 0.015mm	0.031 mm	0.041 mm	0.031 mm	0.041 mm
	Glue Width Left A	5u	0.300 ± 0.050mm	0.260 mm	0.290 mm	0.260 mm	0.290 mm
	Glue Width Left C	5u	0.300 ± 0.050mm	0.262 mm	0.289 mm	0.262 mm	0.289 mm
	Glue Width Left D	5u	0.300 ± 0.050mm	0.260 mm	0.285 mm	0.260 mm	0.285 mm
	Glue Width Left E	5u	0.300 ± 0.050mm	0.262 mm	0.294 mm	0.262 mm	0.294 mm
	Glue Width Left F	5u	0.300 ± 0.050mm	0.264 mm	0.296 mm	0.264 mm	0.296 mm

Description	Characteristics	Sample Size	Ideal Target	POR Mean	New Mean
Dry Measurement	RX BPF Placement X Offset	5u	0.129 ± 0.050mm	0.088 mm	0.112 mm
	RX BPF Placement Y Offset	5u	0.210 ± 0.050mm	0.181 mm	0.210 mm
	RX BPF Placement Rotation	5u	0 ± 1deg	-0.848 deg	0.112 deg
	RX BPF Tilt	5u	Max 0.050mm	0.001 mm	0.006 mm
Destructive Measurement	RX BPF Push Test	5u	Min 0.6 kgf	1.030 kgf	2.393 kgf

4.1.4.2. QUALIFICATION RESULT: Die Attach Yield Monitoring

The results demonstrate that the new epoxy, with a specified volume of 7 grams, has successfully passed the qualification criteria. The die attach process has achieved an impressive yield of 99.97%, with a minimal yield loss of only 0.03%. Furthermore, the average percentage for Time Unscheduled Downtime (TUD) stands at 9.8%. It is important to emphasize that this TUD percentage is not linked to the dispensing process, suggesting that the dispensing operation's reliability remains intact.

Table 9. Qualification result (Yield and TUD checking)

Description	Characteristics	Sample Size	POR Mean 14g	New Mean 7g	Yield (Target >99.75%)	Yield (Target <0.25%)	TUD (Target <10%)
Left Dispenser Wet Measurement	Faied in Glue Height Left A	4 lots/IPQC monitoring	0.047 mm	0.046 mm	99.97%	0.03%	9.80%
	Faied in Glue Height Left C	4 lots/IPQC monitoring	0.045 mm	0.043 mm			
	Faied in Glue Height Left D	4 lots/IPQC monitoring	0.046 mm	0.043 mm			
	Faied in Glue Height Left E	4 lots/IPQC monitoring	0.041 mm	0.041 mm			
	Faied in Glue Height Left F	4 lots/IPQC monitoring	0.044 mm	0.042 mm			
	Faied in Glue Width Left A	4 lots/IPQC monitoring	0.303 mm	0.296 mm			
	Faied in Glue Width Left C	4 lots/IPQC monitoring	0.295 mm	0.291 mm			
	Faied in Glue Width Left D	4 lots/IPQC monitoring	0.293 mm	0.292 mm			
	Faied in Glue Width Left E	4 lots/IPQC monitoring	0.295 mm	0.292 mm			
	Faied in Glue Width Left F	4 lots/IPQC monitoring	0.292 mm	0.287 mm			

Description	Characteristics	Sample Size	POR Mean 14g	New Mean 7g	Yield (Target >99.75%)	Yield (Target <0.25%)	TUD (Target <10%)
Right Dispenser Wet Measurement	Faied in Glue Height Right A	4 lots/IPQC monitoring	0.045 mm	0.044 mm	99.97%	0.03%	9.80%
	Faied in Glue Height Right C	4 lots/IPQC monitoring	0.044 mm	0.044 mm			
	Faied in Glue Height Right D	4 lots/IPQC monitoring	0.045 mm	0.044 mm			
	Faied in Glue Height Right E	4 lots/IPQC monitoring	0.041 mm	0.042 mm			
	Faied in Glue Height Right F	4 lots/IPQC monitoring	0. 044 mm	0.043 mm			
	Faied in Glue Width Right A	4 lots/IPQC monitoring	0.295 mm	0.295 mm			
	Faied in Glue Width Right C	4 lots/IPQC monitoring	0.298 mm	0.295 mm			
	Faied in Glue Width Right D	4 lots/IPQC monitoring	0.287 mm	0.296 mm			
	Faied in Glue Width Right E	4 lots/IPQC monitoring	0.294 mm	0.294 mm			
	Faied in Glue Width Right F	4 lots/IPQC monitoring	0.284 mm	0.290 mm			

4.1.4.3. QUALIFICATION RESULT: Dispenser Wet Measurement POR vs 7g

The gathered data shows that the dimensions of the glue, reflecting the volume of the newly applied epoxy, meet the defined standards and match the Performance of Record (POR). There was a significant variation found in the Glue Height Dimension from the Left Dispenser, but the proposed adjustment has led to decreased variability and has exceeded the POR criteria for consistent performance. (Refer to appendix 10.1)

Table 10. One-way analysis for POR and New Mean.

Source		Dispense Line	Prob > F
Left Dispenser	Glue Height	A	0.4514
		C	0.1501
		D	0.0465
		E	0.9815
		F	0.1545
	Glue Width	A	0.1466
		C	0.4684
		D	0.8685
		E	0.5965
		F	0.2367

Source		Dispense Line	Prob > F
Right Dispenser	Glue Height	A	0.2593
		C	0.8592
		D	0.6255
		E	0.5853
		F	0.6395
	Glue Width	A	0.9062
		C	0.588
		D	1345
		E	0.9969
		F	0.1207

4.1.4.4. QUALIFICATION RESULT: Dry Measurement POR vs New Mean

The assessment confirms that the implementation of the 7-gram epoxy has successfully complied with the qualification criteria. A high yield of 99.97% was observed in the die attach process, alongside a minimal yield loss of 0.03%. The Time Unscheduled Downtime (TUD) averaged at 9.8%, which is significant as it is not linked to the dispensing process, indicating the dispensing operation's stability is maintained with the new epoxy volume.

Table 11. Qualification result (Yield and TUD checking)

Description	Characteristics	Sample Size	POR Mean 14g	New Mean 7g	Yield (Target >99.75%)	Yield (Target <0.25%)	TUD (Target <10%)
Dry Measurement	Glass Placement X Failure	4 lots/IPQC monitoring	0.107 mm	0.111 mm	99.97%	0.03%	9.80%
	Glass Placement Y Failure	4 lots/IPQC monitoring	0.207 mm	0.206 mm			
	Glass Placement Theta Failure	4 lots/IPQC monitoring	0.022 deg	0.008 deg			
	Glass Placement Tilt Failure	4 lots/IPQC monitoring	0.009 mm	0.007 mm			
Destructive Measurement	Low Push Test Data	4 lots/IPQC monitoring	2.143 Kgf	2.206 kgf			

4.1.4.5. QUALIFICATION RESULT: Glass Placement and Destructive Measurement POR vs 7g

Data shows that Dry and Destructive measurement for new epoxy volume are within specs and comparable with POR. (Refer to appendix 10.2)

Table 12. One-way analysis for POR and New Mean

Source	Glass Placement	Prob > F
Dry Measurement	X - Offset	0.3103
	Y - Offset	0.7656
	Rotation	0.3706
	Tilt	0.1706
Destructive Measurement	Push Test	0.7221

Sample data for the POR and New 7g epoxy eval for Glue width and height are Normally Distributed since Goodness of Fit (Prob<W) is >0.05. (Refer to appendix 10.3)

Table 13. Summary of Wet and Dry Measurement ANOVA

Source		Glass Placement	Prob < W
Left and Right Dispenser	Glue Height	A - Left POR	0.1602
		A - Left New 7g Eval	0.9903
	Glue Width	A - Right POR	0.9225
		A - Right New 7g Eval	0.4611
Dry Measurement	Glass Placement	Rotation POR	0.5158
		Rotation New 7g Eval	0.3763

4.1.4.6. LINE STRESS RESULT: Wet Measurement POR vs New Mean

Result shows the new epoxy volume (7g) PASS qualification requirements. die attach Yield is at 99.90%, yield loss at 0.10%. TUD % averages at 4.9%. TUD not related to epoxy weight.

Table 14. Line Stress result (Yield and TUD checking)

Description	Characteristics	Sample Size	POR Mean 14g	New Mean 7g	Yield (Target >99.75%)	Yield (Target <0.25%)	TUD (Target <10%)
Left Dispenser Wet Measurement	Faied in Glue Height Left A	10 lots/IPQC monitoring	0.044 mm	0.043 mm	99.90%	0.10%	4.90%
	Faied in Glue Height Left C	10 lots/IPQC monitoring	0.044 mm	0.043 mm			
	Faied in Glue Height Left D	10 lots/IPQC monitoring	0.045 mm	0.044 mm			
	Faied in Glue Height Left E	10 lots/IPQC monitoring	0.042 mm	0.042 mm			
	Faied in Glue Height Left F	10 lots/IPQC monitoring	0.043 mm	0.043 mm			
	Faied in Glue Width Left A	10 lots/IPQC monitoring	0.299 mm	0.300 mm			
	Faied in Glue Width Left C	10 lots/IPQC monitoring	0.297 mm	0.294 mm			
	Faied in Glue Width Left D	10 lots/IPQC monitoring	0.296 mm	0.292 mm			
	Faied in Glue Width Left E	10 lots/IPQC monitoring	0.293 mm	0.290 mm			
	Faied in Glue Width Left F	10 lots/IPQC monitoring	0.293 mm	0.289 mm			
Description	Characteristics	Sample Size	POR Mean 14g	New Mean 7g	Yield (Target >99.75%)	Yield (Target <0.25%)	TUD (Target <10%)
Right Dispenser Wet Measurement	Faied in Glue Height Right A	10 lots/IPQC monitoring	0.045 mm	0.043 mm	99.90%	0.10%	4.90%
	Faied in Glue Height Right C	10 lots/IPQC monitoring	0.044 mm	0.043 mm			
	Faied in Glue Height Right D	10 lots/IPQC monitoring	0.045 mm	0.044 mm			
	Faied in Glue Height Right E	10 lots/IPQC monitoring	0.043 mm	0.042 mm			
	Faied in Glue Height Right F	10 lots/IPQC monitoring	0.044 mm	0.042 mm			
	Faied in Glue Width Right A	10 lots/IPQC monitoring	0.301 mm	0.293 mm			
	Faied in Glue Width RightC	10 lots/IPQC monitoring	0.293 mm	0.290 mm			
	Faied in Glue Width Right D	10 lots/IPQC monitoring	0.295 mm	0.291 mm			
	Faied in Glue Width Right E	10 lots/IPQC monitoring	0.294 mm	0.292 mm			
	Faied in Glue Width Right F	10 lots/IPQC monitoring	0.293 mm	0.289 mm			

Data shows glue height and glue width for new epoxy volume are within specs and comparable with POR. (Refer to appendix 10.4)

Table 15. One-way analysis for POR and New Mean

Source		Dispense Line	Prob > F
Left Dispenser	Glue Height	A	0.1137
		C	0.1064
		D	0.1126
		E	0.7424
		F	0.6471
	Glue Width	A	0.7415
		C	0.4611
		D	0.354
		E	0.3338
		F	0.2427

Source		Dispense Line	Prob > F
Right Dispenser	Glue Height	A	0.0804
		C	0.1298
		D	0.1924
		E	0.2259
		F	0.0635
	Glue Width	A	0.0604
		C	0.3416
		D	0.3404
		E	0.3577
		F	0.2181

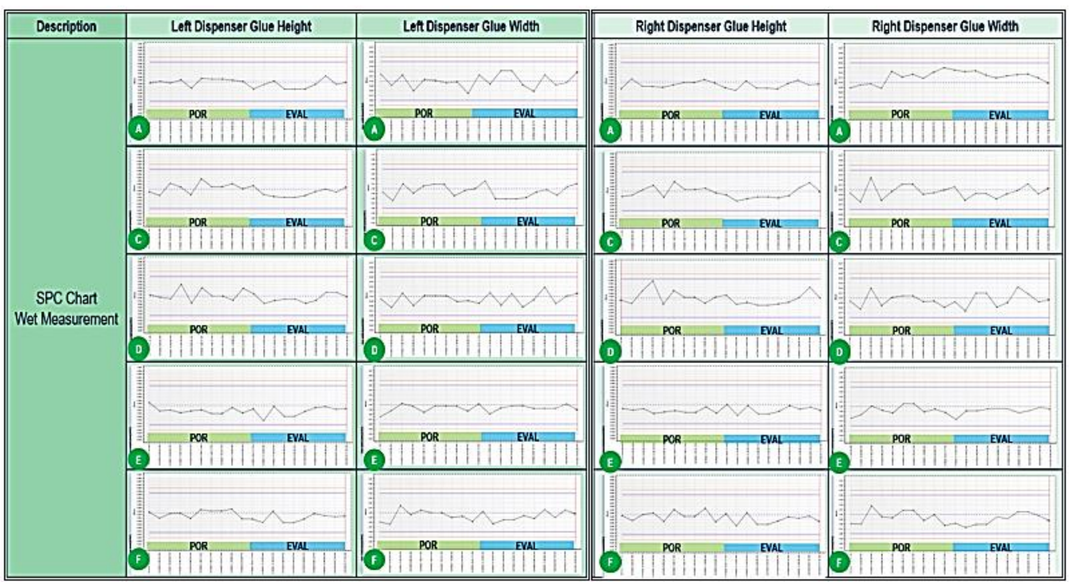


Fig. 3. Wet measurement SPC Monitoring Chart

SPC chart shows that glue height and glue width of both dispenser for new epoxy volume are within control and PASS Cpk. No shift on the process data.
(Refer to appendix 10.5)

4.1.4.7. LINE STRESS RESULT: Dry Measurement POR vs New Mean

Result shows the new epoxy volume (7g) PASS qualification requirements. die attach Yield is at 99.90%, yield loss at 0.10%. TUD % averages at 4.9%. TUD not related to epoxy weight.

Table 16. Line Stress result (Yield and TUD checking)

Description	Characteristics	Sample Size	POR Mean 14g	New Mean 7g	Yield (Target >99.75%)	Yield (Target <0.25%)	TUD (Target <10%)
Dry Measurement	Glass Placement X Failure	10 lots/IPQC monitoring	0.106 mm	0.105 mm			
	Glass Placement Y Failure	10 lots/IPQC monitoring	0.199 mm	0.200 mm			
	Glass Placement Theta Failure	10 lots/IPQC monitoring	0.029 mm	0.051 deg	99.90%	0.10%	4.90%
	Glass Placement Tilt Failure	10 lots/IPQC monitoring	0.008 mm	0.007 mm			
Destructive Measurement	Low Push Test Data	10 lots/IPQC monitoring	2.589 kgf	2.326 kgf			

Data shows that Dry measurement for new epoxy volume are within specs and comparable with POR. Destructive measurement with significant difference between POR data and EVAL data but better performance since Push test data has lower variation. (Refer to appendix 10.5)

Table 17. One-way analysis for POR and New Mean

Source	Glass Placement	Prob > F
Dry Measurement	X - Offset	0.6654
	Y - Offset	0.4755
	Rotation	0.3991
	Tilt	0.4623
Destructive Measurement	Push Test	0.0053

The Statistical Process Control (SPC) chart illustrates that both the dry and destructive test measurements for the new epoxy volume fall well within the control limits and satisfy the Capability Process Index (Cpk) requirements. (Refer to appendix 10.8)

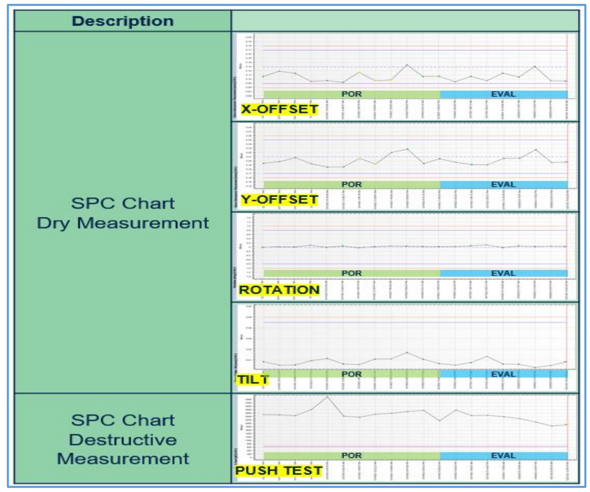


Fig 4. Dry measurement SPC Monitoring Chart

Sample data for the POR and New 7g epoxy eval for Glue width and height Dry measurement are Normally Distributed since Goodness of Fit (Prob<W) is >0.05. (Refer to appendix 10.7)

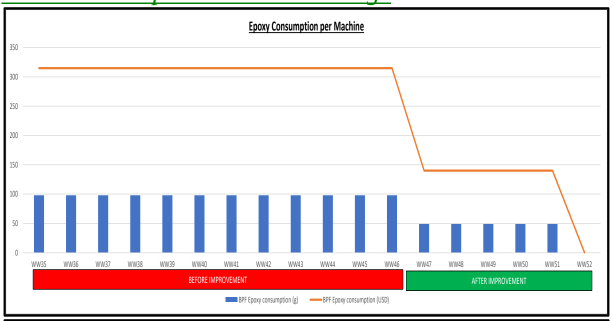
Table 19. Wet and Dry Measurement Anova

Source		Glass Placement	Prob < W
Left and Right Dispenser	Glue Height	A - Left POR	0.554
		A - Left New 7g Eval	0.2374
	Glue Width	A - Right POR	0.523
		A - Right New 7g Eval	0.3033
Dry Measurement	Glass Placement	Rotation POR	0.2688
		Rotation New 7g Eval	0.745

5.0 CONCLUSION

Epoxy, a vital component in the operation of our machines, has traditionally been scheduled for replacement every 48 hours, with the cost of a 7g syringe being $40. However, recent data analysis has revealed that a single machine was consuming an average of 98g of epoxy, which, when calculated using the 14g syringe pricing, amounted to a substantial $315 in epoxy costs. This level of consumption not only had a significant financial impact but also indicated an area where efficiency could be improved. In response to this, measures were taken to optimize the use of epoxy, and these efforts have been met with considerable success. The consumption was effectively halved to 49g per week, which in turn led to a cost saving of $175 per machine. When this figure is extrapolated across the entire fleet of 13 machines that are in operation, the total cost reduction amounts to an impressive $27,300. It is noteworthy that this 56% reduction in both cost and usage comfortably exceeds the initial goal of a 50% reduction. This achievement not only represents a significant financial saving for the company but also underscores the effectiveness of the measures implemented to enhance the efficiency of our resource utilization.

5.1. Actual Impact and Cost Savings



BPF11	WW35	WW36	WW37	WW38	WW39	WW40	WW41	WW42	WW43	WW44	WW45	WW46	WW47	WW48	WW49	WW50	WW51	WW52
BPF Epoxy consumption (g)	98	98	98	98	98	98	98	98	98	98	98	98	49	49	49	49	49	no load
BPF Epoxy consumption (USD)	315	315	315	315	315	315	315	315	315	315	315	315	140	140	140	140	140	no load
												Savings/wk	175	175	175	175	175	#VALUE!
												Savings/wk	56%	56%	56%	56%	56%	

Fig 5. Epoxy Consumption Monitoring

5.2. Impact to the Environment

The environmental impact of materials used in industrial processes is an increasingly important consideration, and this is particularly true for substances such as epoxy, which are integral to the functioning of our machinery. The classification of the epoxy we use takes into account a variety of hazard information pertaining to the ingredients contained within it, as outlined in the Material Safety Data Sheets (MSDS). These sheets provide detailed information based on the classification criteria for mixtures for each hazard class or differentiation, ensuring that all potential risks are thoroughly assessed and managed.

In our commitment to environmental stewardship and responsible resource management, we have undertaken a comprehensive review of our epoxy usage. Through dedicated efforts to optimize our processes, we have successfully reduced our monthly epoxy usage from an average of 98 grams to 49 grams. This remarkable reduction of 56% not only contributes to cost savings but also significantly diminishes our environmental footprint. By minimizing the amount of epoxy used, we inherently reduce the potential for wastage, which, if not managed properly, could lead to Ecotoxicity issues. Ecotoxicity refers to the potential for chemical substances to adversely affect ecosystems, including harm to aquatic life and other organisms that come into contact with these chemicals when they are disposed of improperly.

By halving our epoxy usage, we are effectively lowering the risk of such environmental hazards. This proactive approach to environmental conservation is a testament to our organization's dedication to sustainability and the safeguarding of our natural surroundings. It is a clear demonstration of how environmental responsibility and economic efficiency can go hand in hand, as the reduction in material use not only mitigates potential ecological harm but also aligns with our financial objectives by decreasing operational costs. Our success in this area serves as a model for how industrial processes can be refined to be more environmentally friendly while also enhancing the bottom line.

6.0 RECOMMENDATIONS

6.1. Standardization & Documentation.

To ensure the long-term sustainability of the improvements made in epoxy usage reduction, we have taken a thorough approach to standardization and documentation. This involves a comprehensive review and update of all relevant operational documents, including standard operating procedures (SOPs), work instructions, and training manuals, to incorporate the new guidelines for epoxy usage. These updated documents serve as the definitive guide for maintaining consistency and adherence to the improved processes across the organization.

Subsequent to the documentation update, a detailed deployment and training plan was executed, focusing on the Line personnel who manage epoxy on a daily basis. The plan included not only the distribution of the revised documents but also an extensive training program aimed at ensuring all personnel are well-versed with the new procedures. The training was designed to emphasize the significance of the changes, their rationale, and the practical application within their roles. Following the training, a robust monitoring system was established to evaluate both the quantitative and qualitative aspects of the process improvements, allowing for immediate correction of any deviations and reinforcing the permanence of the enhancements.

Through this comprehensive approach that combines documentation, training, and ongoing monitoring, we solidify our commitment to continuous improvement, operational excellence, and environmental stewardship. By ingraining these improvements into our operational framework, we guarantee their enduring presence, fostering efficiency and sustainability in our processes well into the future.

Table 20. Implementation Plan

ACTIVITY	ACTION	STATUS
DOCUMENT	Updated WI and JI	DONE
DEPLOY	Oriented Operators and Technicians on the Process Change	DONE
DEMONSTRATE	Yield Monitoring and Self Audit	DONE
DISTRIBUTE	Deploy recipe and All BPF attach Machine	DONE

6.2. Self-evaluation and Future Plans.

Based on the comprehensive self-evaluation of our epoxy usage reduction efforts, we recommend the continuation and expansion of the successful strategies that have led to a significant reduction in material usage and cost savings, as well as improved environmental outcomes. These strategies should be documented as best practices and serve as a model for similar future initiatives within the organization. It is imperative to maintain the momentum of these positive changes by integrating them into the standard operating procedures and ensuring that they are communicated across all relevant departments.

In areas where the evaluation has revealed shortcomings or opportunities for further improvement, we recommend the immediate implementation of detailed action plans. These plans should specify the corrective measures needed, allocate the necessary resources, and set realistic timelines for achieving the desired outcomes. The plans must be monitored regularly, and their effectiveness should be evaluated to ensure that the improvements are sustained over time. Additionally, any lessons learned during this process should be captured and shared organization-wide to prevent recurrence of past inefficiencies and to foster a culture of continuous improvement.

Lastly, we recommend the establishment of a leadership development program that encourages team members to take on leadership roles in new improvement teams. This will not only empower individuals and enhance their leadership competencies but will also ensure that a culture of ownership and accountability is ingrained within the team. Investing in our human capital in this manner will not only yield immediate improvements in our processes but will also build a resilient and dynamic workforce capable of driving the organization towards long-term success and adaptability in the ever-evolving business landscape.

Table 21. Team Learnings

What Went Well	What Need to be Improved	Action Plans	Responsible	Status
Added knowledge on Mechanical Improvement	Check other stations need for improvement	Discussion with PE/EE	Joseph/Team	Started
Added knowledge on Process Qualification	Selection of analysis/method to use	Discussion with PE	Joseph/Team	Started
Improved knowledge on Technical Writing	Needs formal training	Mentoring and Regular Discussion	Jhanet/Team	Started

7.0 ACKNOWLEDGMENT

We extend our profound appreciation to the manufacturing operators, whose diligence and precision in executing production tasks have been fundamental to the success of this research. Their unwavering dedication and meticulous execution have provided a solid foundation for the empirical aspects of our study.

We owe a debt of gratitude to the technical staff, whose hands-on expertise and commitment have been pivotal in the practical execution of this research. Their wealth of experience and technical acumen have significantly enriched the quality and substance of our findings.

Our sincere thanks are directed to the process control experts, whose mastery in overseeing the manufacturing processes has been essential. Their vigilant monitoring and analysis have played a critical role in enhancing our understanding of the production dynamics and in refining our data collection processes.

We express our heartfelt appreciation to the engineers, whose analytical prowess and innovative problem-solving have been instrumental in data interpretation and research development. Their collaborative spirit and insightful contributions have shaped the direction and conclusions of our study.

Special recognition is given to the operators responsible for the meticulous implementation of production processes. Their commitment to excellence and provision of critical data have been the bedrock of our applied research efforts.

We acknowledge the operators for their extensive operational knowledge, which has been indispensable in ensuring the accuracy and relevance of our research applications. Their expertise has been a key component in bridging the gap between theoretical research and practical implementation.

Our gratitude extends to the technicians for their adeptness in maintaining and troubleshooting the sophisticated equipment essential to our research. Their prompt and effective interventions have been crucial in maintaining the continuity and integrity of our experimental work.

We commend the technicians for their swift response and resolution of technical issues, which have been vital in ensuring the uninterrupted progress of our experiments. Their skillful support has been a cornerstone in the logistical success of our research activities.

We are thankful for the process control specialists, whose proficiency in meticulous monitoring has provided us with a deeper comprehension of the manufacturing environment.

Their expertise has significantly contributed to the methodological advancements in our data gathering.

We express our gratitude to the engineers for their analytical thinking and innovative methodologies that have been critical in making sense of complex data. Their technical guidance and inventive strategies have been invaluable assets throughout the course of this research.

In conclusion, this research stands as a testament to the collective effort and unwavering commitment of all the individuals involved. It is with their collaboration that we have been able to achieve the goals set forth in this study. We extend our deepest thanks to each contributor for their integral role in the fruition of this research endeavor.

8.0 REFERENCES

1. Understanding Force Field Analysis | SafetyCulture. (2023, December 13). SafetyCulture. https://safetyculture.com/topics/force-field-analysis/

2. Simplilearn. (2023, October 5). SPC charts: Overview, when to use them and how to create them. Simplilearn.com. https://www.simplilearn.com/spc-charts-article#:~:text=SPC%20or%20Statistical%20Process%20Control,the%20vertical%20(y)%20axis.

3. One-Way ANOVA. (n.d.). Introduction to Statistics | JMP. https://www.jmp.com/en_ph/statistics-knowledge-portal/one-way-anova.html#404f1893-ae56-43ed-b84c-f6c99f313eca

9.0 ABOUT THE AUTHORS

Mark Daniel L. Madrid, currently Process Tech II in STMicroelectronics. Assigned in OPS2 Assembly Department and currently in service for 6 years. Received Vocational Course of Electromechanics Technology in Dualtech Training Center. He is now a working student taking up B.S. degree in Mechanical Engineering at Manuel S. Enverga University Foundation.

Joseph C. Suarez, currently Sr. Process Tech in STMicroelectronics. Assigned in Test and Finish Department and currently on service for 7 years. Received B.S. Degree in Industrial Engineering from University of Perpetual Help System Dalta.

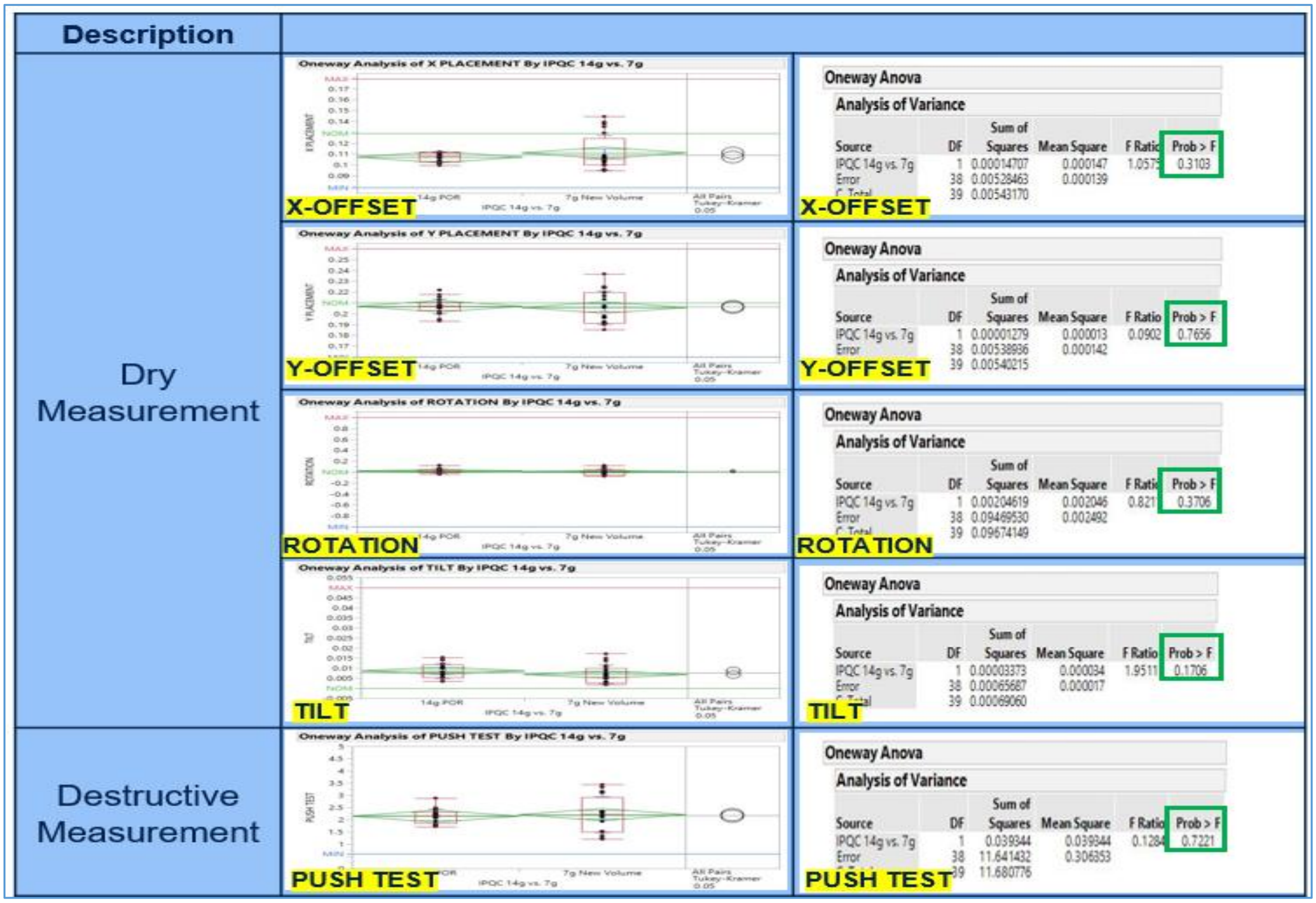
Rosalinda F. Frayres, currently Process Tech II in STMicroelectronics. Assigned in OPS2 Assembly Department and currently in service for 5 years. Received B.S. Degree Major in Electronics in Sorsogon State University.

10.0 APPENDICES

10.1 One-way Analysis for Wet Measurement

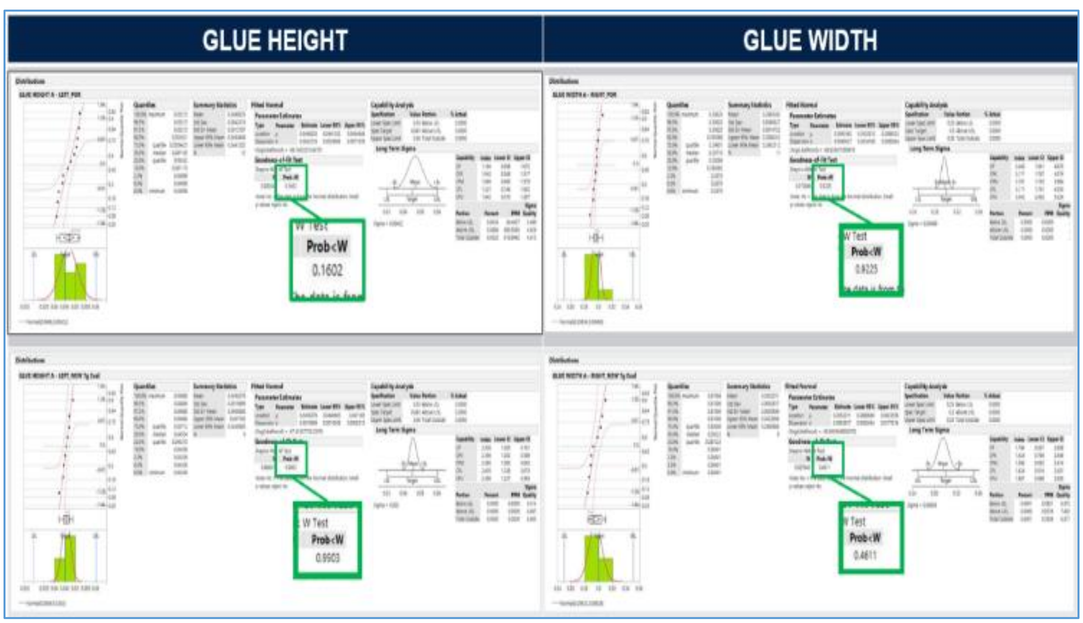
Data shows glue height and glue width for new epoxy volume are within specs and comparable with POR

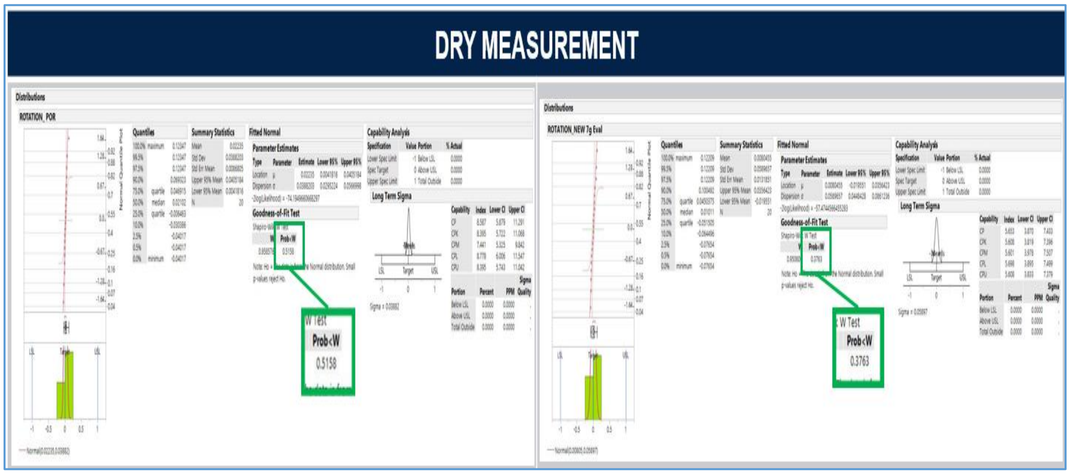
10.2 One-way Analysis for Dry and Destructive Measurement



Data shows that Dry and Destructive measurement for new epoxy volume are within specs and comparable with POR.

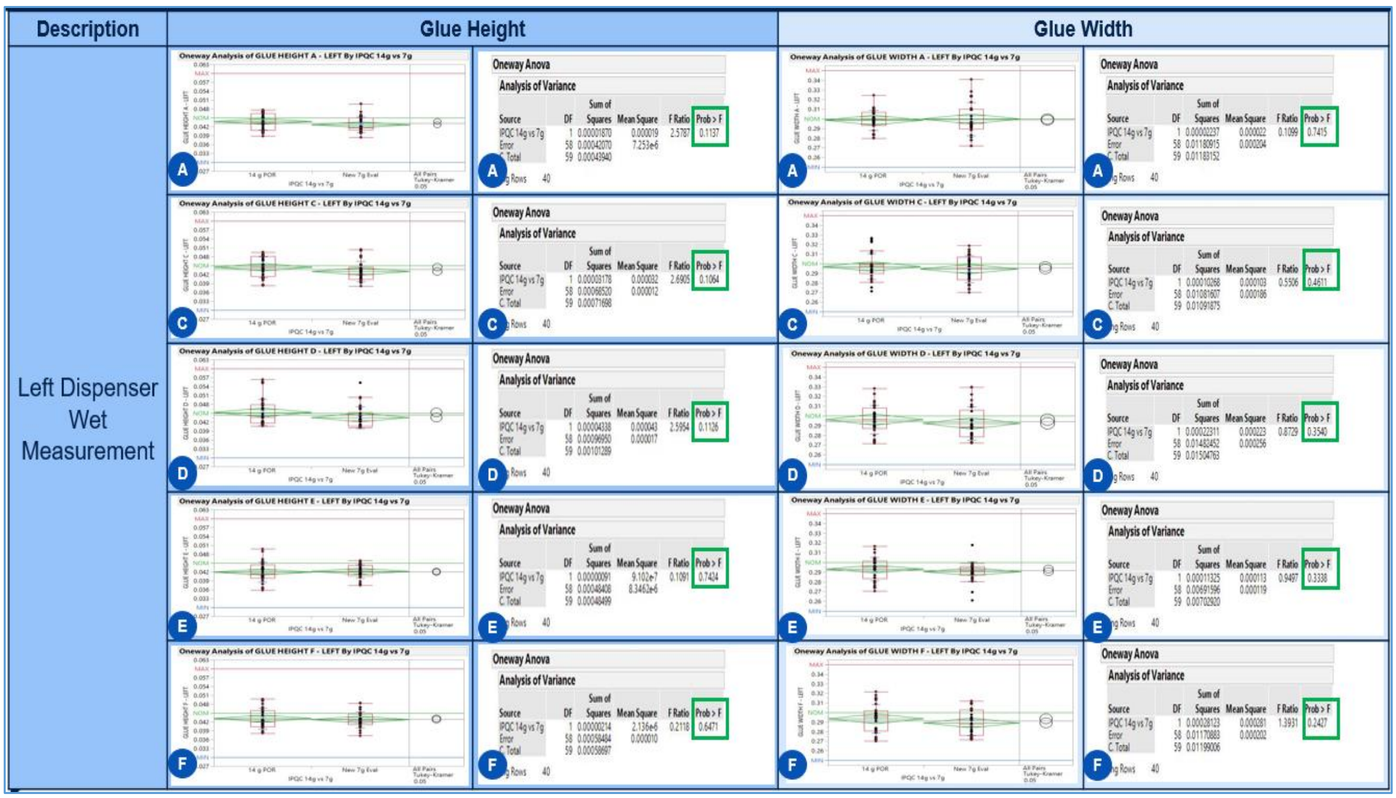
10.3 Wet and Dry Measurement Anova

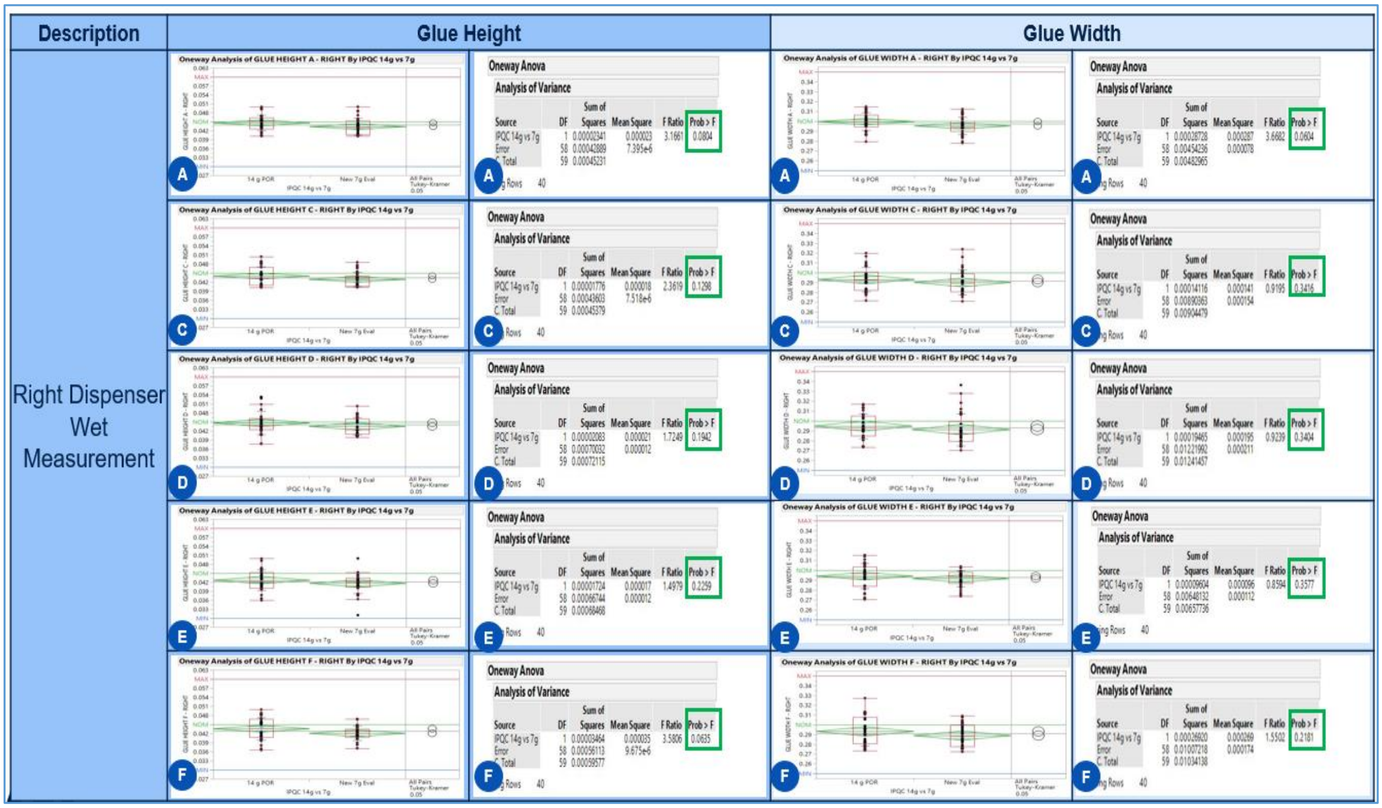




Sample data for the POR and New 7g epoxy eval for Glue width and height are Normally Distributed since Goodness of Fit (Prob<W) is >0.05.

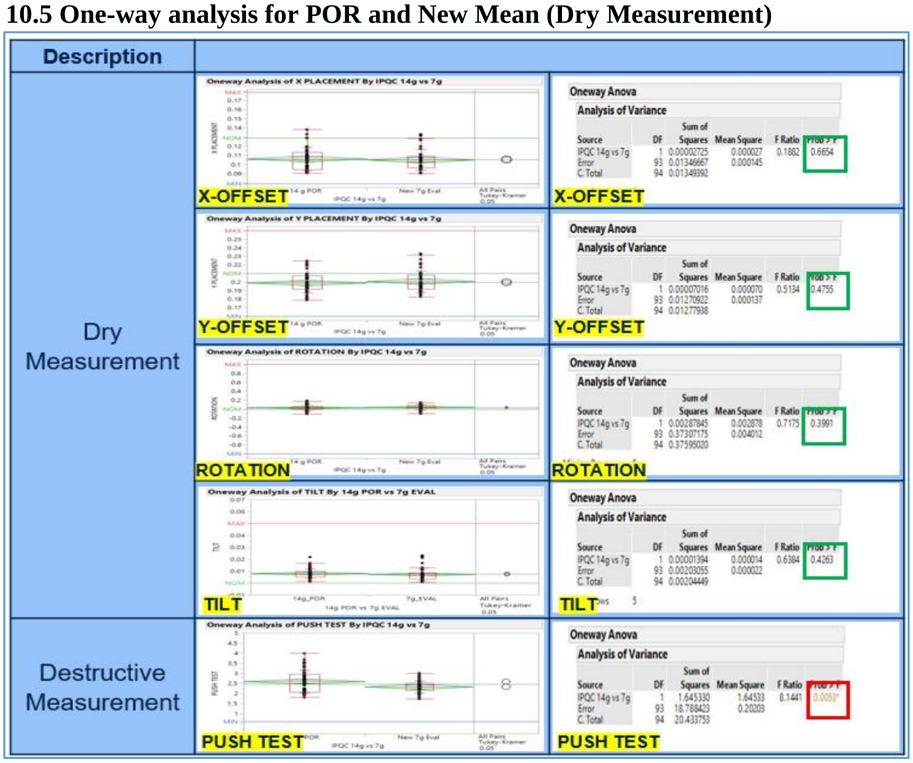
10.4 One-way analysis for POR and New Mean (Wet Measurement)





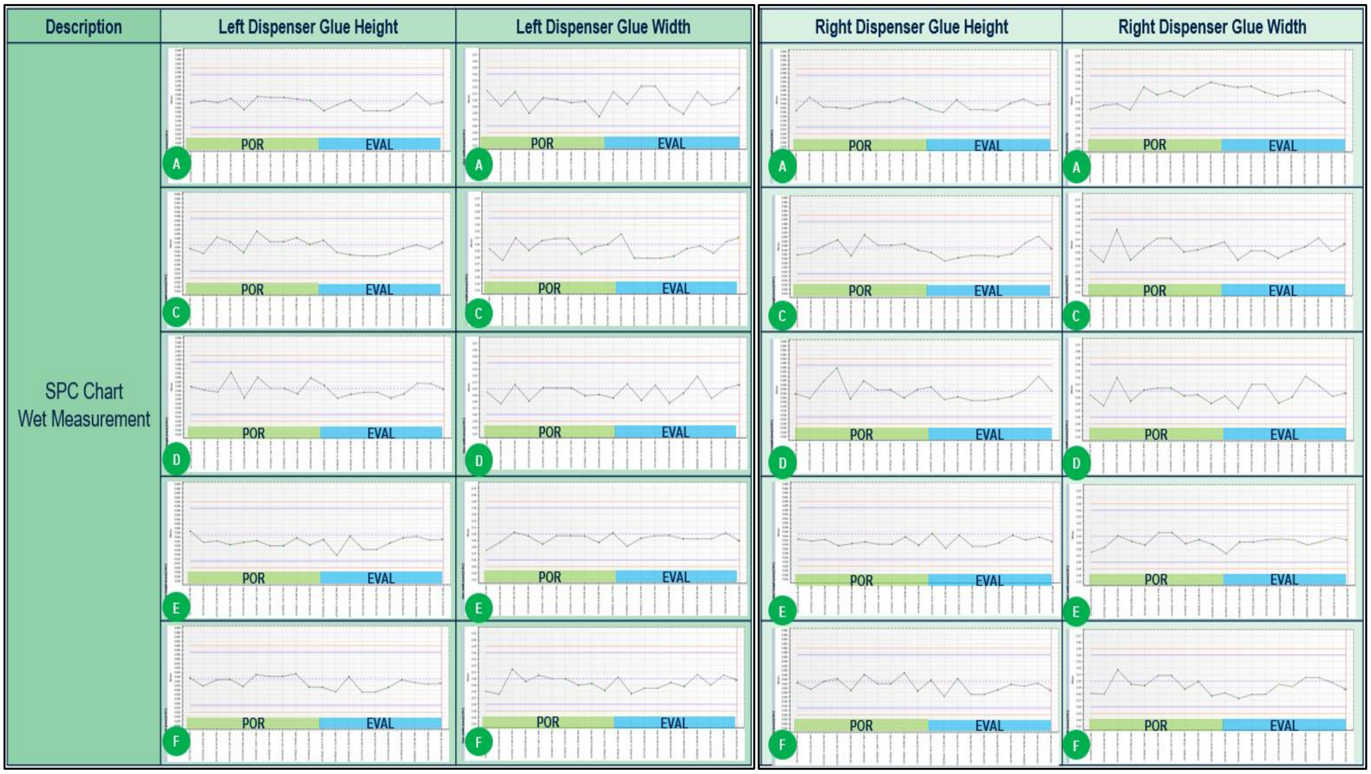
Data shows glue height and glue width for new epoxy volume are within specs and comparable with POR.

10.5 One-way analysis for POR and New Mean (Dry Measurement)

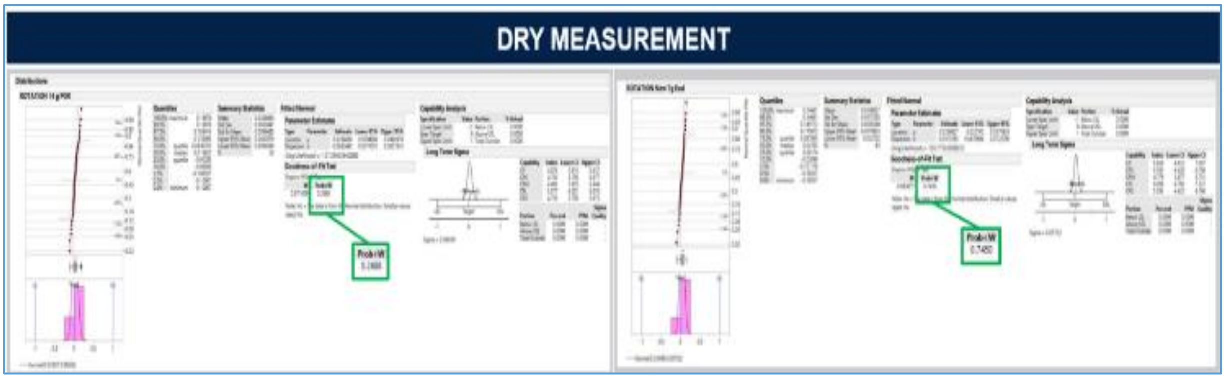


Data shows that Dry measurement for new epoxy volume are within specs and comparable with POR.

10.6 Dry measurement SPC Monitoring Chart



10.7 Wet and Dry Measurement Anova



Sample data for the POR and New 7g epoxy eval for Glue width and height Dry measurement are Normally Distributed since Goodness of Fit (Prob<W) is >0.05.

10.8 Wet and Dry Measurement Anova