PROJECT TITLE:
Travan TR7 Dynamic Electrical Test Failure Reduction

TEAM : *Elite Sigma*

MEMBERS:

Name	Position	Responsibility
Joel Amil	Process Eng'g. Manager	Team Leader
Johnny Ledesma	Process Engineer	Mechanical Issues (FA/CA)
Ernesto Manuel	Process Engineer	Electrical Test Issues (FA/CA)
Eric Maligaya	Customer Interface	Mechanical Issues (FA/CA)
Lito Suba	Test-Section Manager	Electrical Test (Equipment and Setup
Marvin Marte	QA Manager	Customer Interface

MEETING TIME / VENUE:

Place:	Joel Amil's room
Schedule:	Monday's through Fridays
Time:	1245H to 1400H
Attendance:	88.7%
Start Date:	Dec. 2002
End Date:	Feb. 2003

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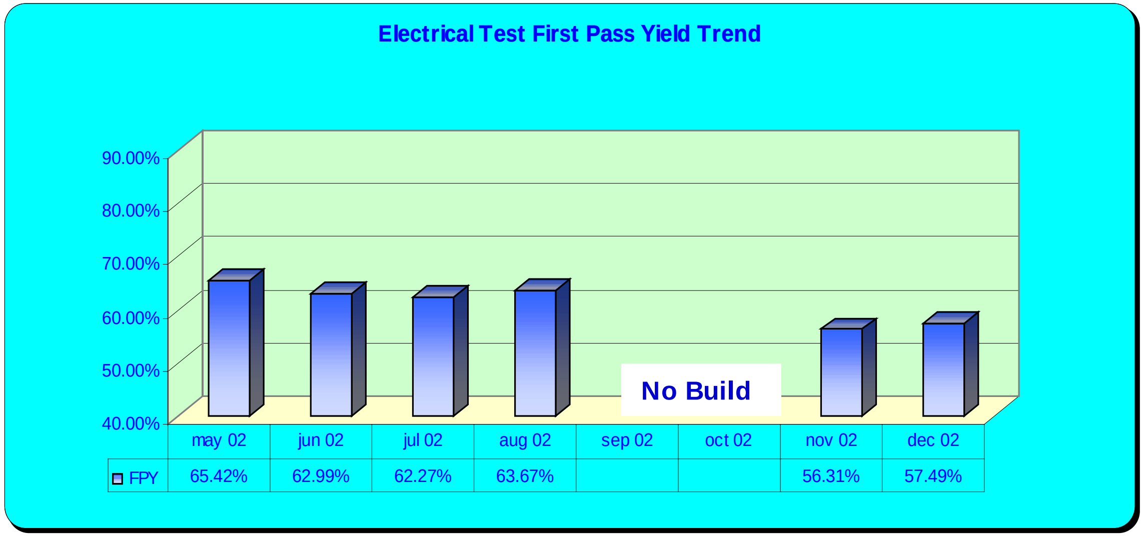
1.0 INTRODUCTION:

Read-Rite Philippines is the manufacturing site for Tape Head Business Unit,and the core competency is assembly and test. Read-Rite (Tape Head Business Unit) manufactures magnetoresistive (MR) tape heads to the entry level through mid-range tape drive markets, with products such as Travan, DLT (Digital Linear Tape), SLR (Scalable Linear Recording) and SDLT (Super DLT).

In order to become competitive in the market, QUALITY, COST and DELIVERY performance must be world-class. This case study describes the low first pass yield problem at Final Test station (Travan TR7), which is one of the major sources of high-cost-manufacturing, and how it was solved.

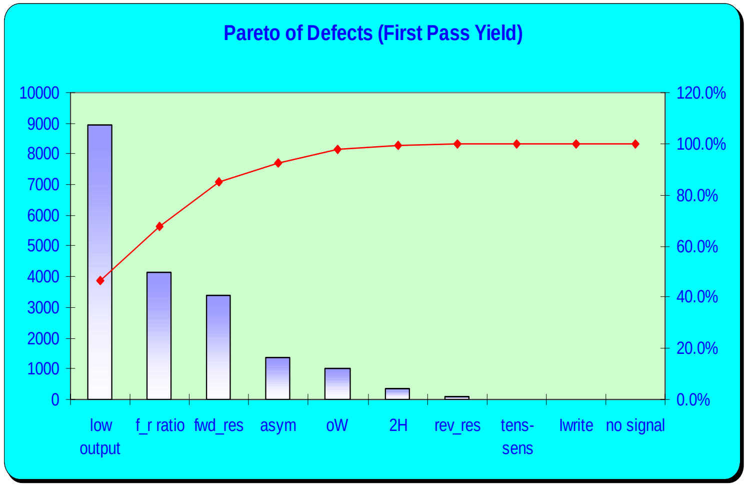
1.1 Yield

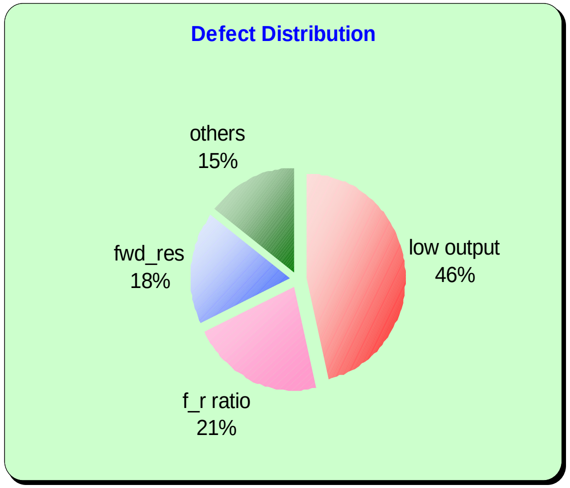
TR7 tape heads are used for Travan 40 tape drives which offer up to 20 Gbytes native storage capacity (40 Gbytes compressed). Seagate Line, Travan TR7 product First Pass Yield at Dynamic Electrical Test (DET) shows a stable but low trend at an average of 61% as shown in the graph below.



1.2 Pareto of Defect

Pareto chart shows the dominant failures are Low Output (f_out and r_out), Fwd_rev ratio (f_r ratio) and Forward Resolution (fwd_res). These three defects comprise the vital few equivalent to 85% of the problem.





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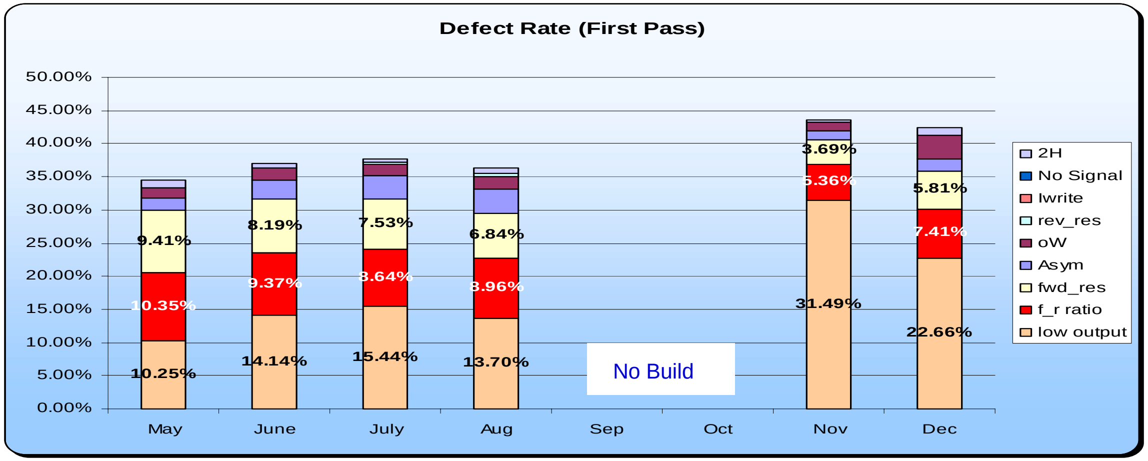
1.3 Defect Rate

- Chart below shows the hierarchy per defect (Average defect rate from May to Dec).
  1. low output = 22% failure rate
  2. f_r ratio = 9% failure rate
  3. fwd_res = 5% failure rate
  4. Others = 3% failure rate



1.4 Definition:

Output Voltage is defined as the quotient between the High Frequency measurement output by the gain of the test pre-amp and filter circuit.

Forward/Reverse ratio mismatch is calculated from the signal output in the forward and reverse direction.

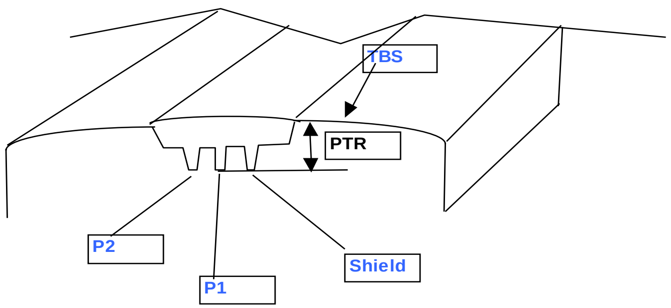
Fwd/Rev Ratio (%) = (MAX Output - MIN Output) * 100 / MAX Output

Resolution shall be measured as the ratio of the Fd signal amplitude, divided by the write-equalized Fd/8 signal amplitude.

Physical manifestations and engineering attributes:

Output is a measure of the output voltage at the head's highest Recording Density. Output depends on the ability of the head to read a very small (weak) signal that was written to and stored on the magnetic tape. The closer the tape is to the head or the better the contact between the tape and the head, the stronger (large) the signal is and the higher the output.

Resolution and output are quite related. The process induced parameters that will affect them are: PTR (Pole Tip Recession), stripe height, spacing (contour affecting tape/head interface). PTR will affect both the output and resolution (resolution is ratio of HF output to LF output) while, contour in particular how the gap is centered will affect relative response in FWD or REV direction.



Cross-sectional view of TR7 head

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2.0 OBJECTIVE:

2.1 To improve First Pass Test Yield from ~61% to 90% (29% improvement) by January 2003.

DET Parameters	From	To	Gain
low output	22%	7%	15%
f_r ratio	9%	1%	8%
fwd_res	5%	1.5%	3.5%
others	3%	0.5%	2.5%
Total	**39%**	**10%**	**29%**

3.0 EXPERIMENTAL SECTION:

3.1 SIPOC (Supplier-In-Process-Out-Customer)

Tape Polish

⇨

Carriage Bond

⇨

Electrical Test

Tester	GRnR			Control
	PTR	Radius	Apex Offset	
WYKO MHT III	9.09%	6.67%	14.53%	X-bar and R

Tester	GRnR	Control
	Roll	
Heighmatic	19.93%	100% test

Tester	GRnR			Control
	f_out	r_out	f_res	
HTU 528	18.95%	16.15%	19.70%	100% test
HTU 566	10.56%	13.28%	18.27%	100% test
HTU 583	10.50%	12.31%	19.67%	100% test
HTU 573	10.83%	10.96%	18.93%	100% test

3.2 Root Cause Analysis

Design of Experiment (Paired Comparison/Tukey Test) Methodology was used to analyze the problem. Wherein 7 good heads and 7 bad heads were simultaneously collected at Final Test station. The samples were arranged in ascending order with respect to the mechanical independent variables. As indicated in the table below, PTR shows as the RED-X (Red X refers to the root cause of the problem) at 98% confidence level.

Radius and Apex Offset are showing slight significance at about 70% confidence, factorial design is necessary.

Red X

98% Confidence Level

	PTR (µ")	MR (Ω)	Radius (in.)	Apex Offset (in.)	Roll (in.)
	-0.65 G	70 B	0.042 B	-0.0001 B	-0.0002 B
	-1.07 G	71 B	0.044 B	0.00002 B	-0.0002 G
	-1.07 G	71 G	0.0442 G	0.00002 G	0 B
	-1.22 G	72 B	0.0445 B	0.00004 G	0 G
	-1.34 G	72 B	0.0445 G	0.0001 B	0.0001 B
	-1.63 G	72 G	0.045 B	0.0001 B	0.0001 B
	-1.68 B	72.5 B	0.045 B	0.0001 B	0.0001 B
	-1.82 B	72.5 G	0.045 B	0.0001 G	0.0001 G
	-1.9 B	72.5 G	0.045 G	0.0001 G	0.0001 G
	-1.96 B	72 G	0.045 G	0.0001 G	0.0001 G
	-1.96 G	73 B	0.045 G	0.0002 B	0.0002 B
	-1.97 B	73 G	0.0451 B	0.0002 B	0.0002 B
	-1.99 B	74 B	0.0452 G	0.0002 G	0.0002 G
	-2.16 B	74.5 G	0.0455 G	0.0004 G	0.0002 G
Top End Count	6		2	2	
Bottom End Count	3		2	2	
Total End Count	9	Overlapped	4	4	Overlapped

Tukey Table

Total End Count	Confidence Level
5	81%
6	90%
7	95%
10	99%
13	99.99%

3.3 Full Factorial Design

3.3.1 To test if radius and apex offset are important factors on DET parameter responses, while blocking the PTR as one of the factors.

3.3.3 Design (2 levels, 2 factors, 4 responses, 1 middle)

		Factors		Responses			
Run	Pattern	Radius (in.)	Apex Off (in.)	f_out	r_out	f_r ratio	fwd res
1	12	0.038	0.0009				
2	11	0.038	-0.0009				
3	22	0.056	0.0009				
4	21	0.056	-0.0009				
5	00	0.046	0.000				

3.3.4 Result:

Factor A Radius (in.)	Factor B Apex Offset (in.)		Response 1 f_out (mV)	Response 2 r_out (mV)	Response 3 f_r (%)	Response 4 fwd_Res (%)
Lo	Hi		2.14	2.1	1.87	120.59
			1.97	1.9	3.95	69.69
			2.16	2.17	8.46	74.89
			0.78	0.8	2.5	29.16
		Avg	1.76	1.74	[illegible]	73.83
		Stdev	0.68	0.64	[illegible]	38.88
Lo	Lo		2.45	2.35	4.88	98.57
			0.77	0.69	2.82	24.48
			2.03	2.06	1.46	85.73
			2.23	2.32	3.88	71.57
		Avg	1.88	1.86	[illegible]	[illegible]
		Stdev	0.78	0.79	[illegible]	[illegible]
Hi	Hi		2.35	2.39	1.87	79.39
			2.3	2.35	2.13	75.88
			2.32	2.29	1.72	73.94
			2.37	2.51	5.98	90.99
		Avg	2.34	2.38	[illegible]	[illegible]
		Stdev	0.03	0.10	[illegible]	7.79
Hi	Lo		2.07	2.39	8.61	73.84
			2.08	2.43	15.23	79.3
			1.5	1.96	23.47	57.82
			2.35	2.47	4.86	93.57
		Avg	2.00	2.29	[illegible]	[illegible]
		Stdev	0.36	0.23	[illegible]	[illegible]
Med	Med		2.42	2.49	2.42	78.77
			2.16	2.37	8.86	88.87
			2.59	2.57	8.77	85.78
			1.92	2.19	11.83	60.34
		Avg	2.27	2.40	[illegible]	77.44
		Stdev	0.29	[illegible]	[illegible]	[illegible]

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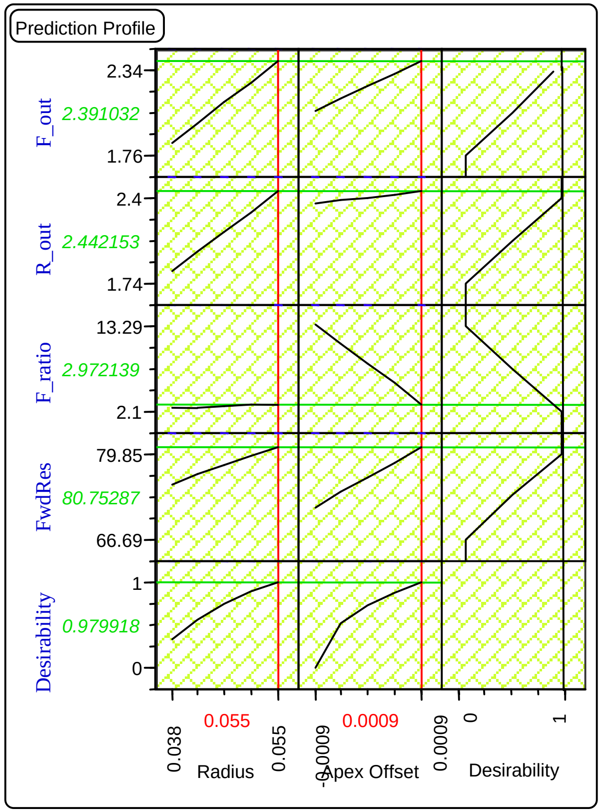
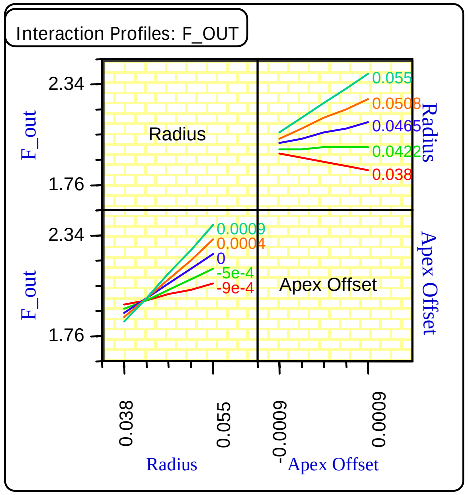
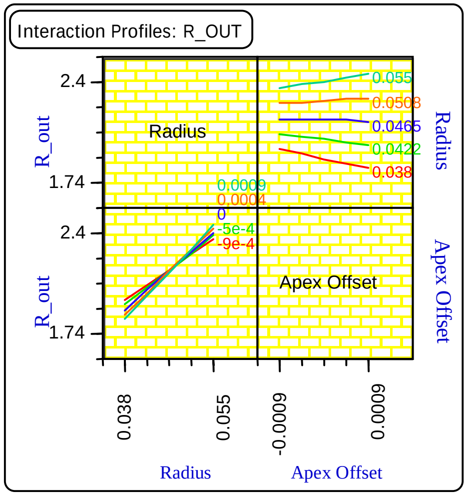
PREDICTION PROFILE

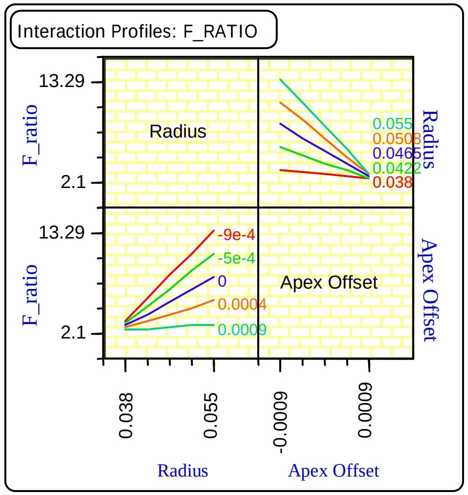


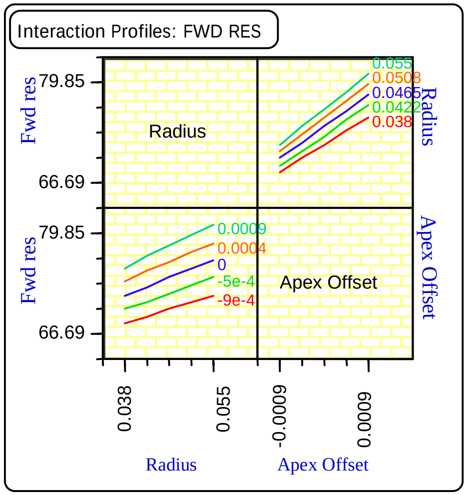
Most Desirable in Grid Setting
Radius : High
Apex Offset : High

INTERACTION PLOT









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3.3.5 Analysis of results :

3.3.5.1 Jump software was used to analyze data.

3.3.5.2 Both radius and apex offset are active factors on all selected responses.

3.3.5.3 Radius being the active factors for both f_out and r_out while Apex offset for both f_ratio and fwd resolution.

3.3.5.4 Most desirable grid setting based on prediction profiler showed that :

Radius : High

Apex : High

3.3.6 Validate Result :

- Confirm through B Vs. C (B = Better, C = Current).

	Radius	Apex Offset
Set B	Hi	Hi
Set C	Mid	Mid

- Sample size = 12 at 95% confidence level

		f_out	r_out	f_r	fwdRes
Set B	Ave	2.19	2.38	7.78	77.53
	Stdev	0.45	0.49	4.78	17.48
Set C	Ave	2.07	2.19	5.69	68.80
	Stdev	0.46	0.49	2.99	16.58
t Statistics		0.61	0.92	1.29	1.26
ß	5%				
DF	11				
Critical Region	2.07				

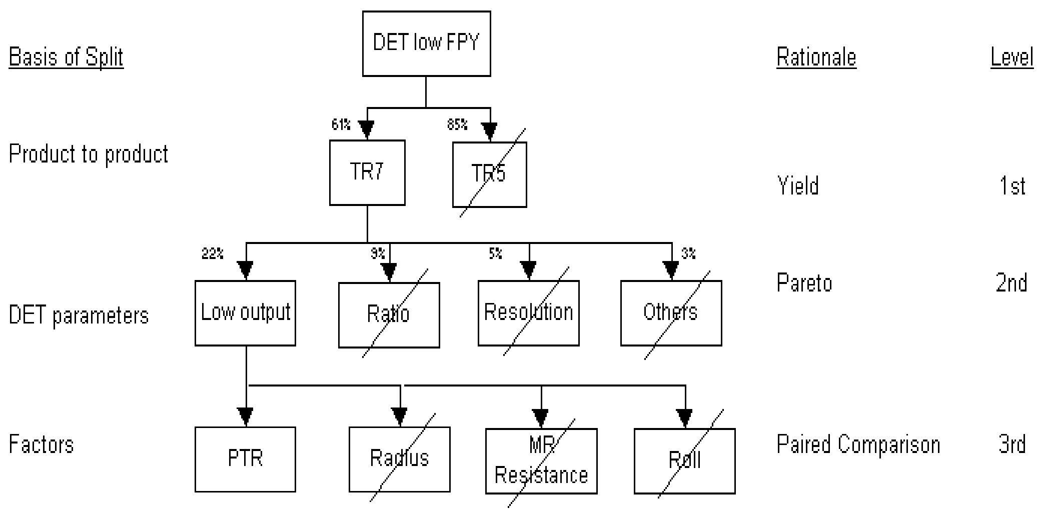
Insignificant

4.0 RESULTS AND DISCUSION:

Paired comparison (Good vs. Bad) Tukey analysis revealed that PTR is the Red X.
Blocking the PTR as a factor, Full Factorial Design showed that Radius and Apex Offset are significant factors (Radius = High; Apex Offset = High). However, validation run using B vs. C and two tailed hypothesis test shows that B process can give the same result as of C or current process.

Step by step investigation is shown in the Solution Tree below.

Solution Tree



5.0 IMPROVEMENT ACTION:

5.1 Change PTR spec from -2.5 µ” minimum to -1.5 µ” minimum spec.
Who: Ernie M.
When: ww16
Status: Implemented

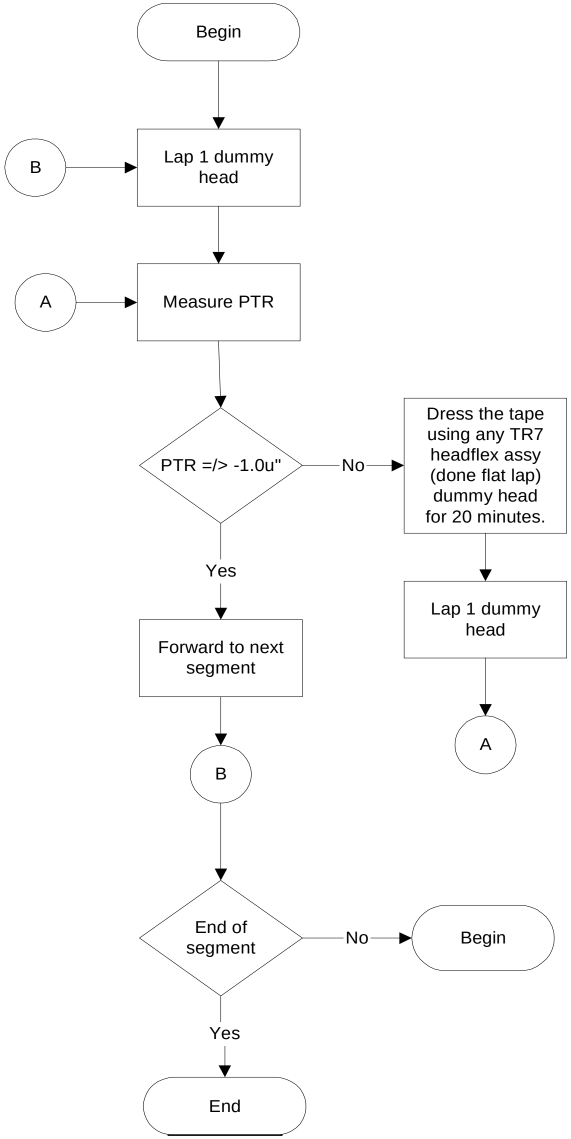
6.0 CONTROL PLAN:

6.1 Perform 100% PTR check at the source (Tape Polish).
Who: Wyko operator
When: ww16
Status: Implemented

6.2 Incoming diamond tape dressing.
Who: Tape Polish Operator
When: ww17
Status: Implemented

6.3 SPC - X bar and R chart.

Diamond Tape Preparation Dressing Flow



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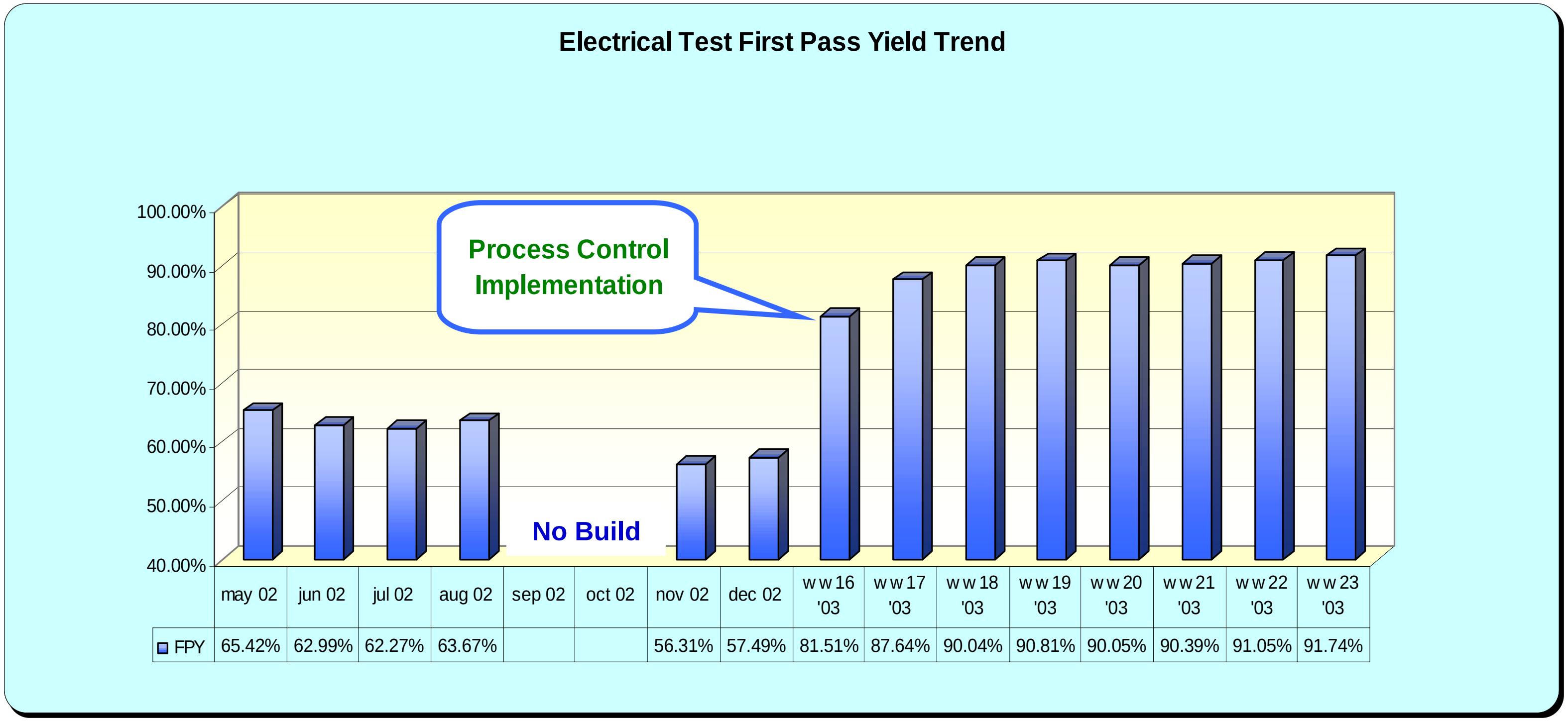
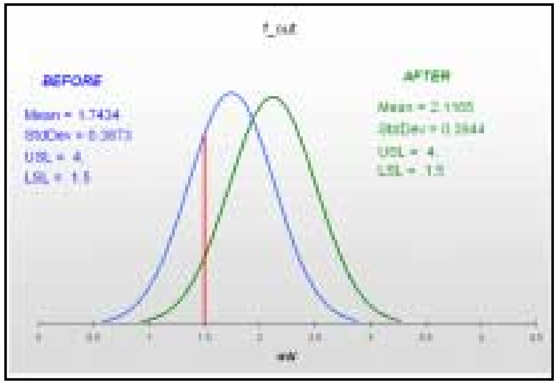
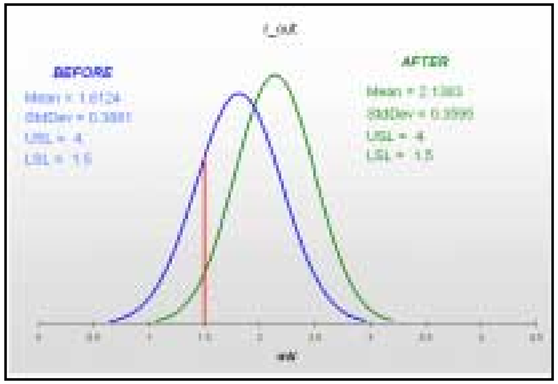
7.0 VERIFICATION

7.1 DET First Pass Yield:



7.2 Comparison of Means Before and After Implementation:



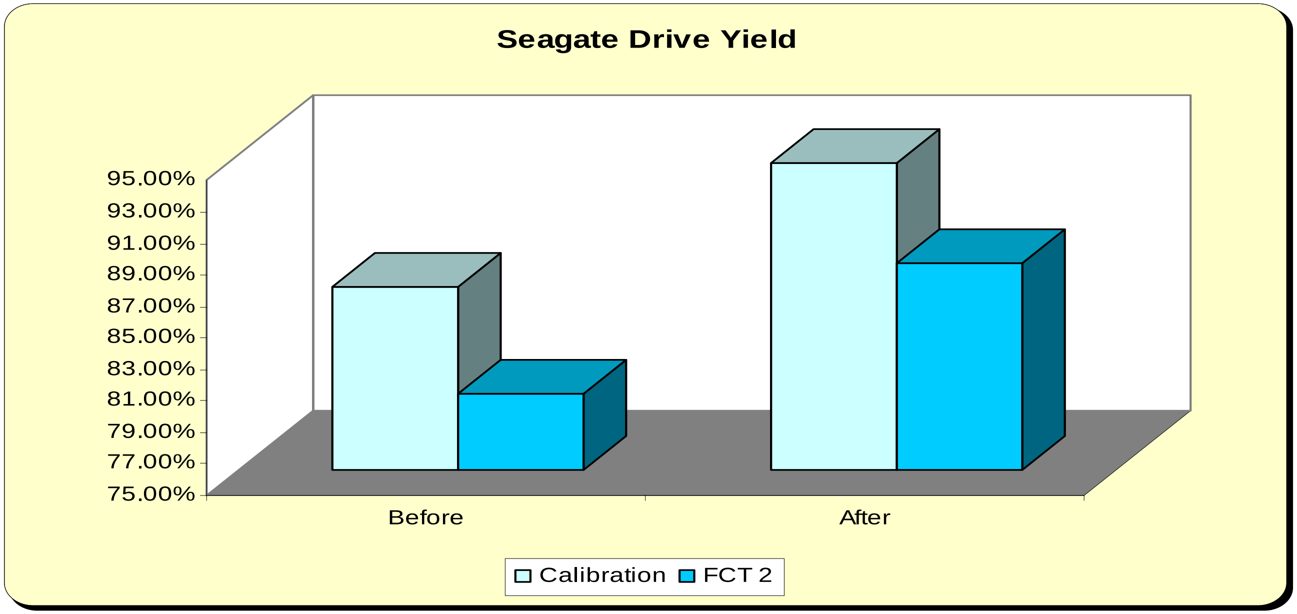


		f_out	r_out
BEFORE	Ave	1.74	1.81
	Stdev	0.39	0.39
AFTER	Ave	2.10	2.12
	Stdev	0.43	0.40
t_o		**6.12**	**5.50**

DF	99
Critical Region	1.98
β	0.05

Significant Change

7.3 Customer Yield:



	WW 18	WW 19	WW 20	WW 21	WW 22	WW 23	WW 24	WW 25	WW 26	WW 31	WW 32	WW 33	WW 34	WW 35	WW36
Calibration	86.88%	86.31%	92.18%	94.55%	93.80%	93.47%	94.69%	94.89%	94.64%	97.19%	91.15%	94.23%	96.82%	91.78%	100.00%
FCT 2	75.80%	83.78%	85.59%	92.61%	88.12%	92.26%	91.54%	87.67%	85.07%	90.64%	89.89%	89.31%	85.61%	82.47%	85.42%
Calibration	86.59%		94.50%												
FCT 2	79.79%		88.17%												

8.0 CONCLUSION:

8.1 Controlling the PTR (Pole Tip Recession) from the source (Tape Polish) has been proven to provide beneficial impact to:

- Improved First Pass Yield (FPY) by 29%.
- Average output voltage increased from 1.7mV TO 2.1mV.

9.0 RECOMMENDATION:

9.1 Fan out improvement action and control plans to Travan 5 Program.

10.0 BUSINESS AND FINANCIAL IMPACT:

Cost Savings of $ 0.41 Per Unit.

Quarterly Savings of $20.5K.

$0.41/Unit x 50K order = $20.5K

11.0 DELIVERABLES:

11.1 Increased DET First Pass Yield by 33X.

11.2 Predictable test result will enable the factory to consistently provide Seagate an average output of above 2.0 mV.

11.3 Increased in capacity in DET provides flexibility to convert from one program to another.