Chapter 3

HGA System Analysis

3. System Analysis

3.1 Overview

The HGA system analysis in this study involves users'function, factors that affect to test performance of recording head products and product measurement as described in HGA process aspects in item 3.2 and procedures for problem solving. The purpose of the analysis is to determine what information is required to improve product quality and decision making or problem solving process.

There are three groups of people who are involved in product performance test. They are organized into functional departments as follows:

1) *Quality Assurance group*: They deal with all activities concerned with the achievement of product quality includes inspection and testing activities

2) *Process Engineering group*: They are involved with all aspects of manufacturing technology including design, facilities layout, procedures, specification, process /product improvement, productivity (yield) and product technology, product cost, product evaluation and so on.

3) *Test Engineering group*: They the technical oriented people who support testing technology including electric tester development and maintenance, test standards and test process analysis and improvement. They are also responsible for engineering information system group, which includes engineering database and applications for monitoring and analysis.

The concern people in those three groups can be categorized into two sorts, which are managers and non-managers. They all associate with product test analysis to identify the problem and improve productivity called "yield" and quality. The diversity of these people causes a need to determine a common model of information systems of recording head performance test to support their activities.

3.2 HGA Process Aspects

HGA process aspects are the HGA test performance effects, which must be interfaced to make sure the information system is developed appropriately.

Recording head manufacturing contains activities to produce and add value to products that can be described by a model demonstrated in figure 3.1. It shows the linkage, reaction and basis of activities. Supporting from engineering group to improve product performance whereas product reports and process capabilities are its supporting tools.

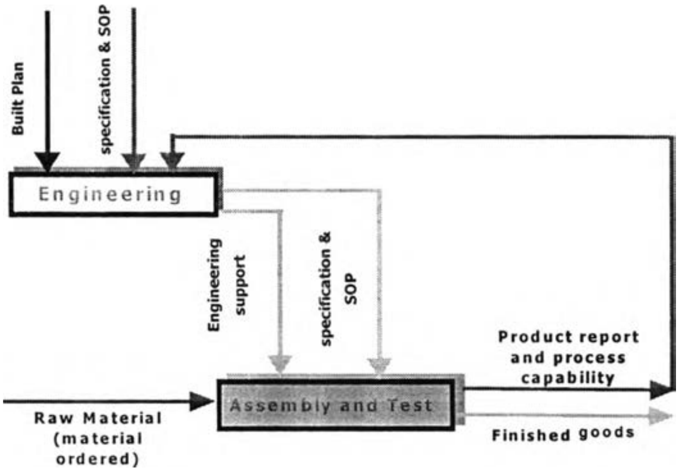


Figure 3.1 A model of HGA process manufacturing

Electrical test operation is performed after assembly on every single HGA, to make sure their quality before ship out to customers. Even though, the test operation is considered as the non-value added operation, it however provides the meaningful information about the product performance used for upstream manufacturing. It can tell some problems in some parts of hard disk assembly process flow as drawn in figure 3.2 via the good managed and utilized entire data. There are however some reasons technically in data connection of the entire hard disk assembly process. It cannot establish immediately where and what the root cause is. Analysis is therefore the necessary activity to utilize data downstream to wafer fabrication.

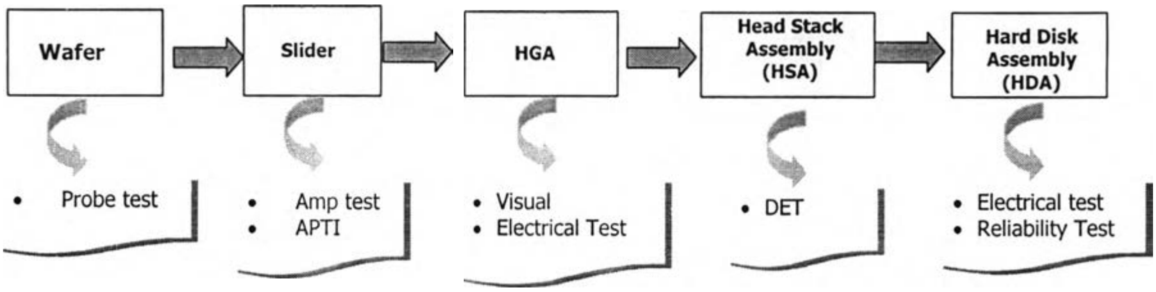


Figure 3.2 Hard Disk Assembly (HDA) Process Flow
(FA Engineering STTH-T [5])

3.2.1 HGA Assembly Process Flow

In HGA area, the process flow can be drawn simply as shown in figure 3.3. It describes how the material flows including rejects from either visual inspection or electrical test operations. For the reworked material, they will be re-flow back to the assembly line. If this case, engineers usually monitor its performance, which is poorer than new material.

Besides, it showed the HGA performance data from the electrical test operation, is collected in database and be typically used by engineering. However, there was constraint in the existing system using is using to support day-to-day activities or further improvement only instead of taking action real time.

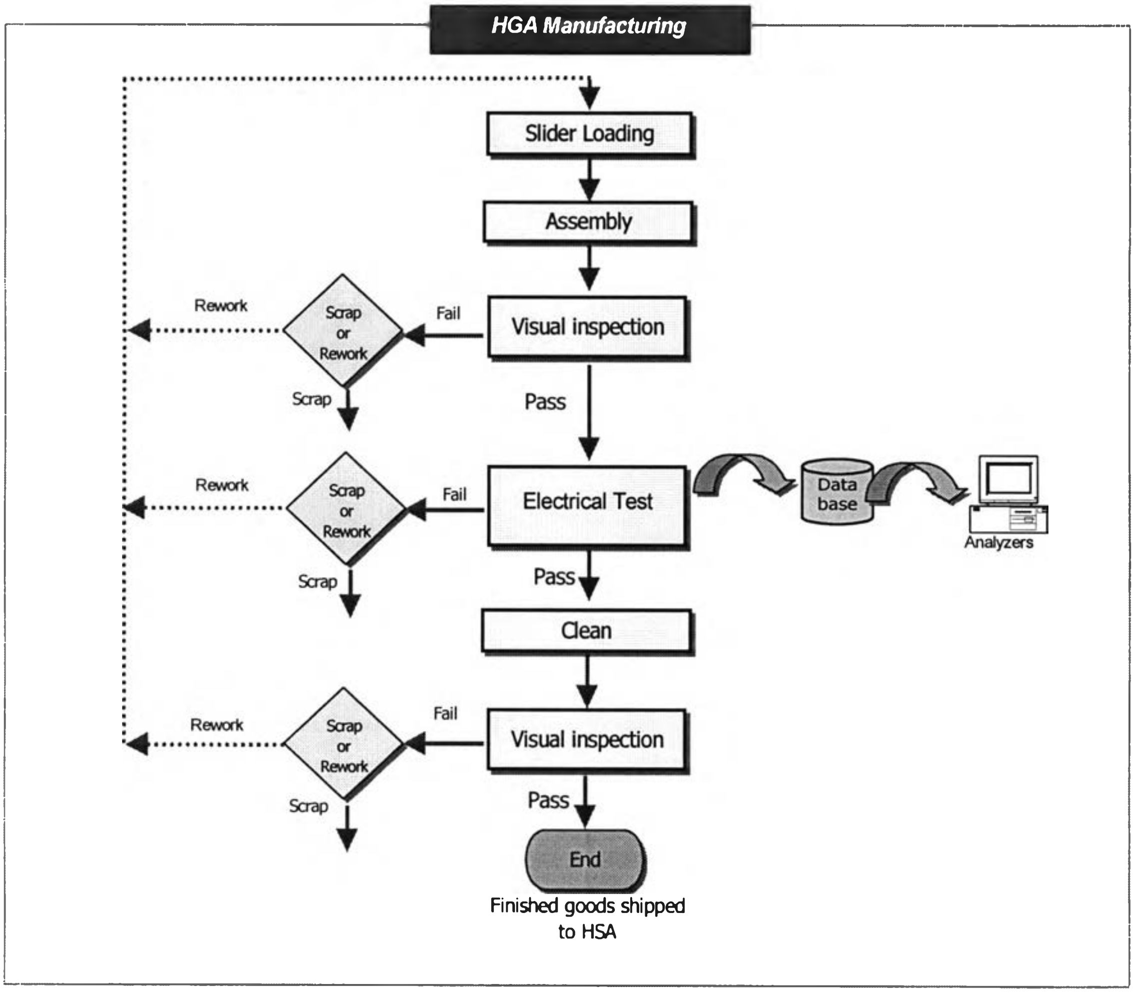


Figure 3.3 HGA Assembly Process Flow
(FA Engineering STTH-T [5])

3.2.2 HGA Quality Aspects

Quality is defined in various ways. In a general sense, it may be defined as meeting the customers' expectations but more specific required in customer mind. In practical purpose, quality has several dimensions, may be used anytime such as support, fitness for use, value and conformance to specifications.

Today's quality becomes a responsibility within organization. Everyone in the organization must aware of quality control. Errors or defects should be caught and corrected at the sense not passed along to an customer. The firm should avoid to get rid of defective products after all operations performed. Similar to HGA manufacturing, it performs electrical test on every single unit of HGA, before ship out to assembly as HSA the next operation. However, according to some technical reasons to connect the information among wafer, slider and HGA sites as mentioned in item 3.2, it is allowed to let some defectives flow. The focus can be now reducing the defective by feed back to the previous operations (wafer and slider manufacturing). Hence, the way to feed back is determining the suspected root cause that can be classified into 2 categories as internal and external problems. Internal problem is results from defects that are discovered during the production of a product. External problem is a result from defects that contributes to quality of design or raw material, which can be either wafer or slider. Both of them affects to yield loss which will be discussed in the following items.

As figure 3.4 shows, several root causes impact to yield losses can be grouped into internal and external causes.

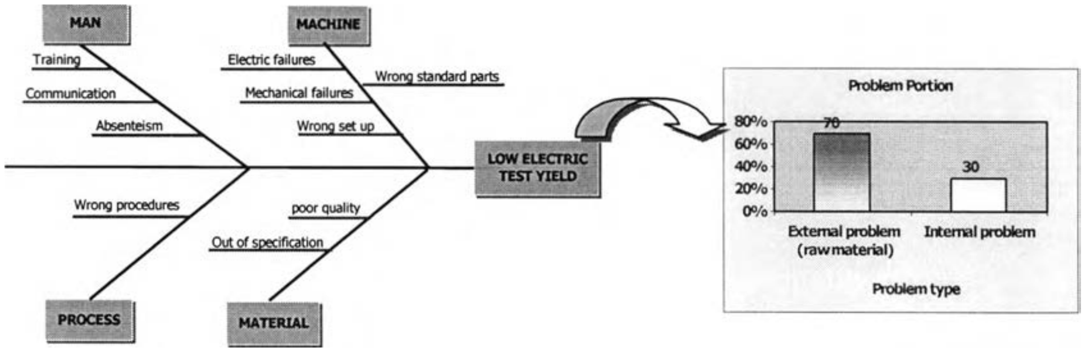


Figure 3.4 Root cause categories in HGA operation

3.2.2.1 Wafer and Slider

Wafer and slider, the incoming material of HGA, has most effect to HGA test performance. Its performance is well established by HGA parametric test and yield.

Each product has its specific product code. Some products may have more than one product code according to the purposes of either different design or sequential tracking. It is found that the quality or performance of different product code on the same product is sometimes different. Therefore, it is considered as a variable that affects to HGA performance and must be reported. See figure 3.5 shows electrical test yield of 2 different product code of Cheetah 18 product.

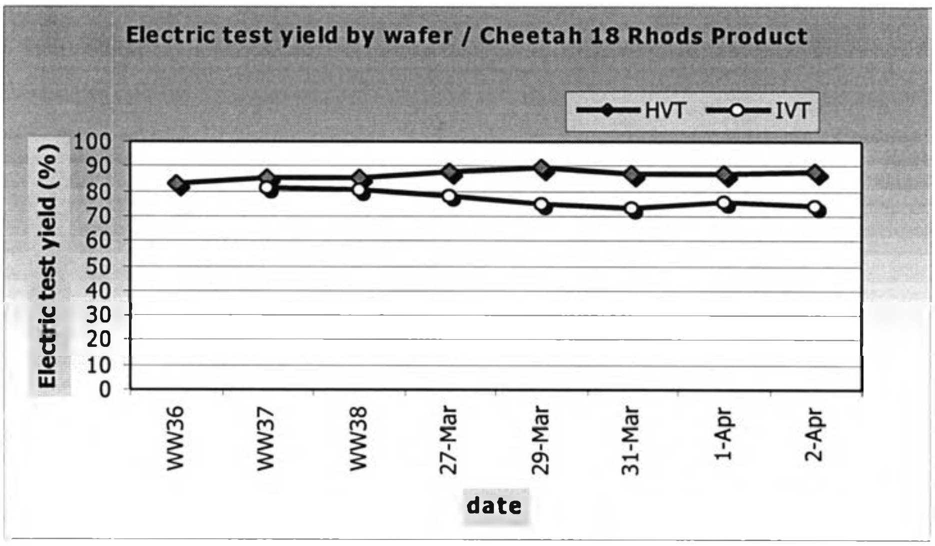


Figure 3.5 Electrical test yield comparison of different product code of Cheetah 18 product

3.2.2.2 Material Type

Material types are categorized based on sliders base which can be grouped into 3 major types; prime, reclaimed and evaluation groups as listed below.

1) Prime sliders are the new sliders which is never used before.
2) Reclaimed sliders are prime HGA failures that be sent to reclaim process for second use. However, not every product can be reworked, depends on slider designed.
3) Evaluation sliders are prime sliders but be used for evaluation purpose.

All types above may perform product test performance differently. However, in separating test performance of each material type in the information system, the standard instruction is required and acknowledged to the concerned people. As a result, TMWI (Tracking Manufacturing Work Instruction) is the standard tool used.

As shown in figure 3.6 is an example of Cheetah18 product, yield impacted by reclaim material

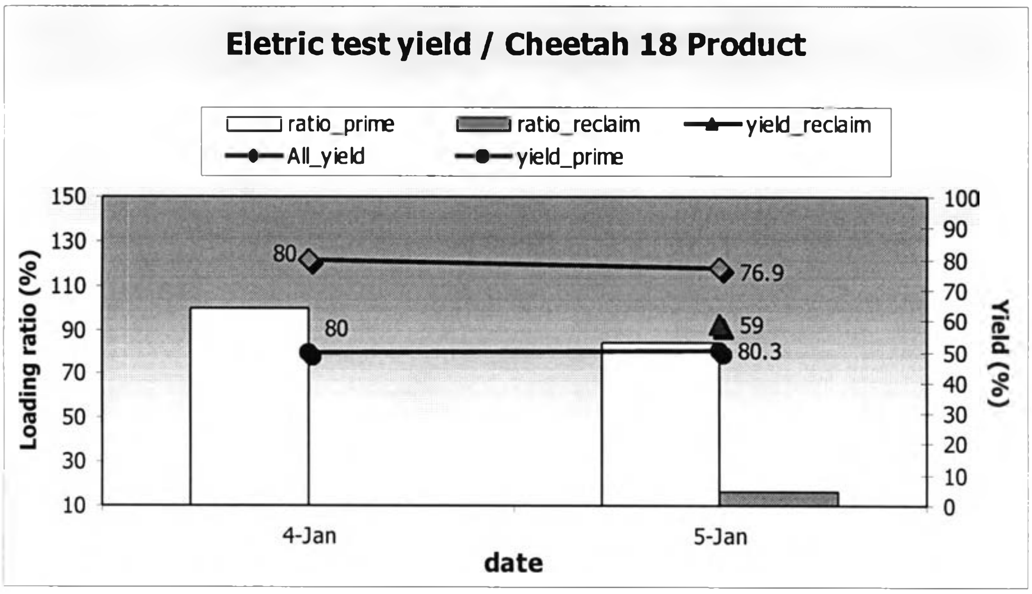


Figure 3.6 shows electric test yield impact by reclaimed material used

3.2.2.3 Assembly Line

An assembly line for producing HGA is started from loading sliders, assembly with FOS and suspension, test and visual inspection. It covers the entire assembly process flow in a single assembly line called a cell as described in figure 3.7, which also contain 5-6 electrical testers in each cell.

Each product may have more than one assembly line (cell) depends on the volume build or customer requirement. One assembly line typically has a capacity at 100,000 HGA build per day. Therefore, the higher the volume build, the higher the number of assembly lines.

Sometimes, there may be problems observed as assembly line dependent which possibly contributed by assembly processes, operators, electrical testers and so on. Consequently, assembly line number is requested from process engineering to record and report in the information system. The purpose is to simplify analysis, which scope of problem. At this stage, TMWI is also used. As shown in figure 3.8, HGA performance is assembly line dependent; assembly line #1 (the pink color) is the poorest one.

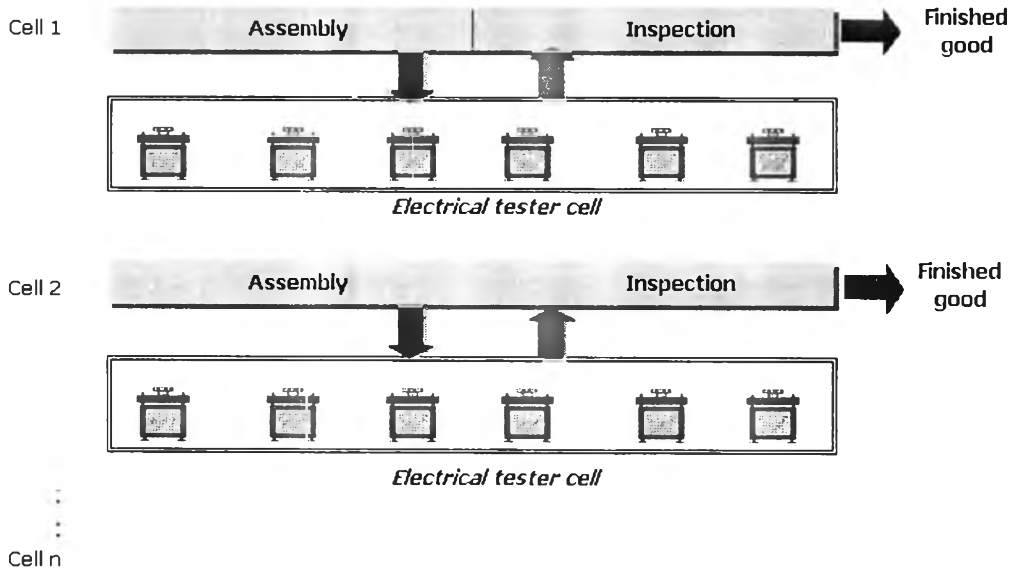


Figure 3.7 Assembly flow layout of each product

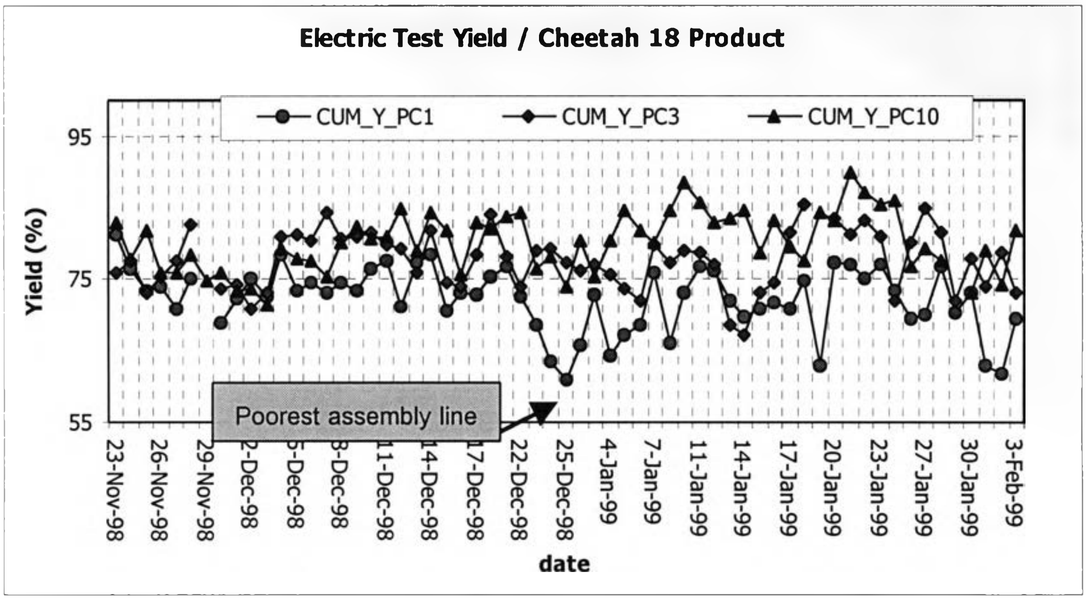


Figure 3.8 HGA performance affected by cell dependent

3.2.2.4 Testers

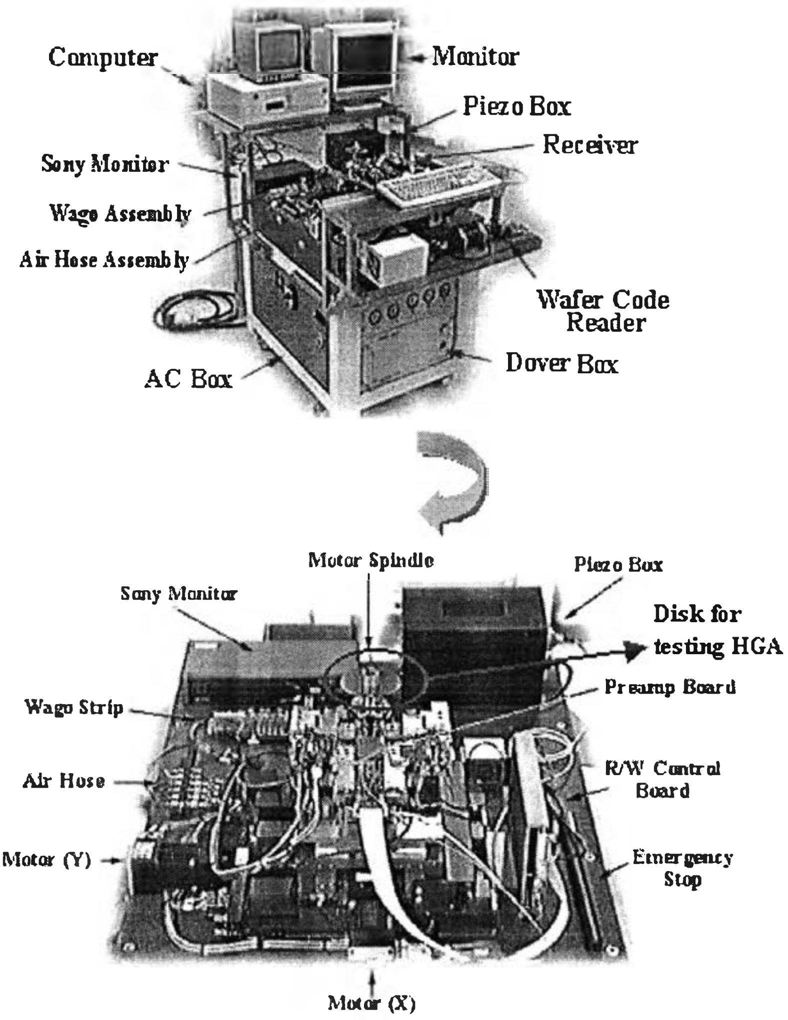
Electrical tester is electromechanical test equipment for performing HGA parametric tests utilizing rotating disk media and electromagnetic recording technology. The design is such that modularity, adaptively and programmability allow the electrical to test a wide range of HGA product families without the need of major and costly redesign. The electrical tester consists of 2 main parts. The first part called "spin-stand", is common to all models with no modification even though the test requirement may change from one product family to another.

The second part is called "Product Module". The product module is dedicated package necessary to facilitate the specific physical requirement of different HGA families. The product module will include electric and software package modifications.

The electrical tester plays a major role in the disk drive manufacturing. Following are some process improvement activities for which the HGA is accountable.

1) Improve communication with design engineer
2) Improve feedback between subassemblies and drives
3) Improve failure analysis
4) Control HGA build process
5) HGA characteristics are known
6) Reduce drive rework
7) Improve process problem response time
8) Increase quality and save cost

As shown in figure 3.9 is the electrical tester used for testing HGA in production line.



Top View

Figure 3.9 Electrical tester used for testing HGA in production line (FA Engineering STTH-T [5])

Typically, an electrical tester must be qualified prior to release to manufacturing to minimized unexpected impact which can be drawn into the simplified workflow in figure 3.10.

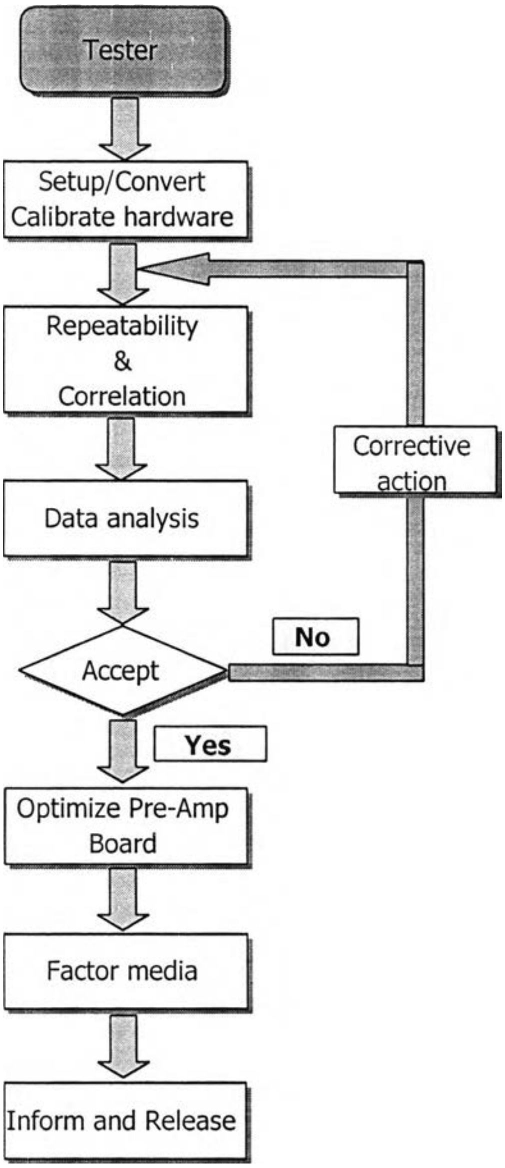
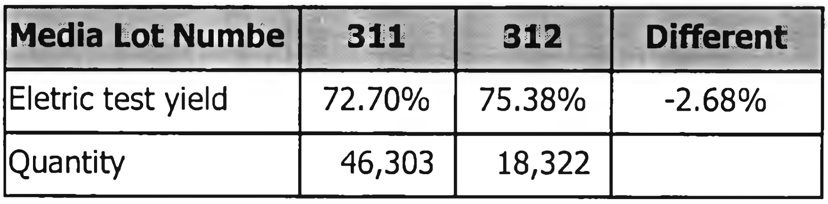


Figure 3.10 Electrical tester release flow
(FA Engineering STTH-T [5])

After testers are released to production, there are changes in manufacturing environment that therefore requires continually exercises of factoring media, media changes and tester optimization activities performed on testers. However, those activities may impact negatively to HGA. Since it requires very high skill and technical knowledge people, which is now behind the technology including the design center area.

As demonstrates in figure 3.11, the negative yield impact is caused by tester association which is media lot #311 compared to lot #312, -2.6% electrical test yield impacted.



Media Lot Numbe	311	312	Different
Eletric test yield	72.70%	75.38%	-2.68%
Quantity	46,303	18,322	

Figure 3.11 Impact from media lot #311, yield loss -2.68%

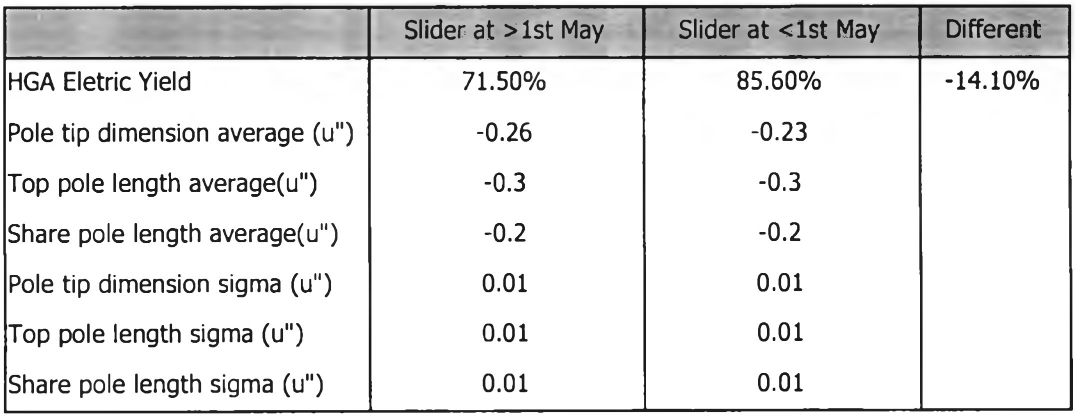
From all above, it can be drawn in the simply diagram of the contribution from internal and external variables as shown in figure 3.12.

Variable		Contribution
External	1) Wafer 2) Slider	Process variation Process variation
Internal	1) Material loading ratio	High/low
	2) In process	Mechanical, Operator, Electrostatic discharge
	3) Tester	Hardware, software
	4) Tester associates	Media, factoring, Optimization
	5) Environments	Noise, vibration, contamination

Figure 3.12 Contribution from internal and external variables

The analysis to determine root cause of low electrical test yield of HGA is sometimes very complicate such as two case study described next. That limits to the development of information system to support engineering groups. Hence, internal/external analysis base is used in troubleshooting problems.

The first example showed HGA test yield impacted -14% from sliders processed at slider process in the time frame of beyond 1st May. The physical dimension does not indicate evidence of defects as shown in figure 3.13.



	Slider at >1st May	Slider at <1st May	Different
HGA Eletric Yield	71.50%	85.60%	-14.10%
Pole tip dimension average (u")	-0.26	-0.23	
Top pole length average(u")	-0.3	-0.3	
Share pole length average(u")	-0.2	-0.2	
Pole tip dimension sigma (u")	0.01	0.01	
Top pole length sigma (u")	0.01	0.01	
Share pole length sigma (u")	0.01	0.01	

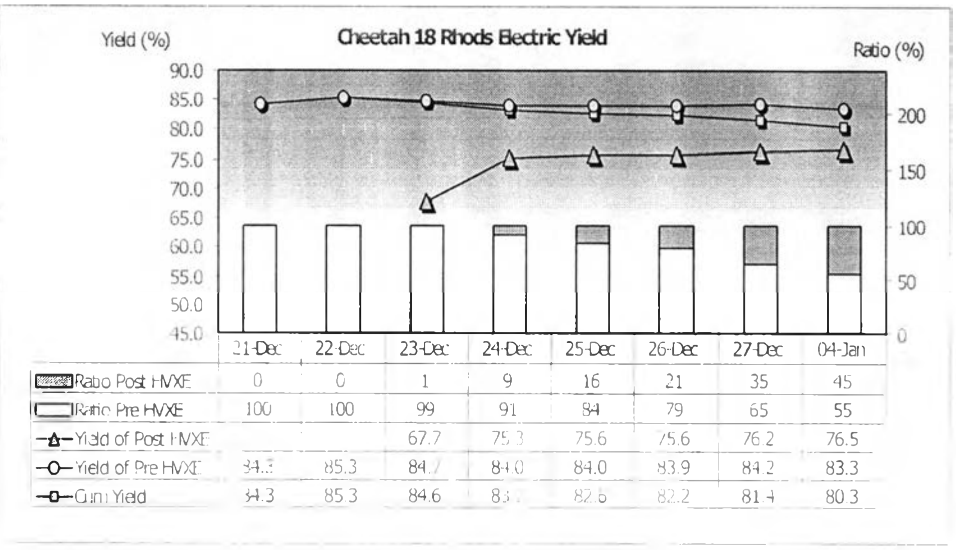
Figure 3.13 HGA yield analysis impacted by unknown root cause, not observe evidence of physical dimension defects

The second example shown below also suggests unknown root cause from data analysis.

Electrical test yield was dropped continually starting from 24th Dec onwards as shown in figure 3.14. Analysis steps are shown below to determine the root cause, which is complicate according to complicate structure of recording head.

1) Yield Analysis:

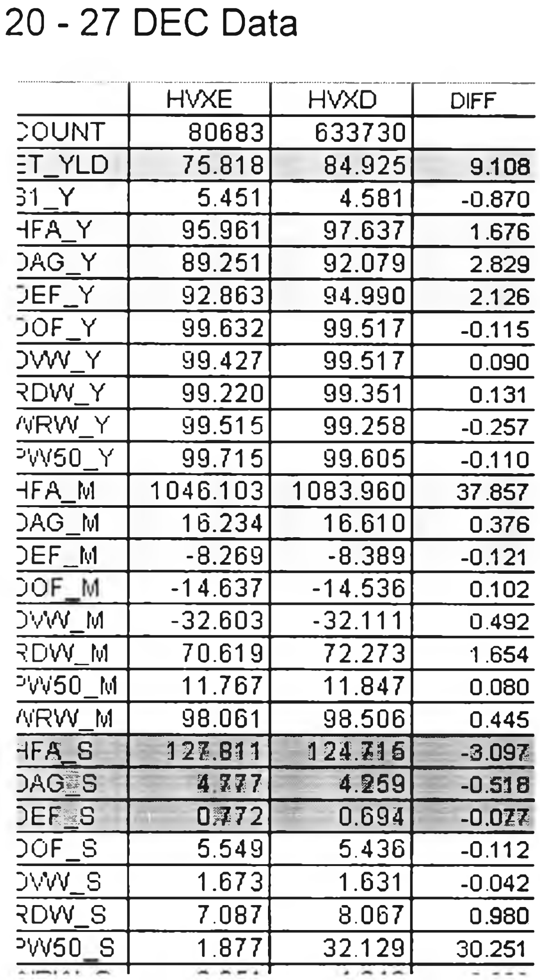
Internal/external analysis showed the contribution by external source. Further analysis performed indicated electric performance was degraded on the higher sequence of wafer serial number. As shown in figure 3.16, the wafer serial number post HVXE was degraded compared to the pre HVXE.



	21-Dec	22-Dec	23-Dec	24-Dec	25-Dec	26-Dec	27-Dec	04-Jan
▨ Ratio Post HVXE	0	0	1	9	16	21	35	45
☐ Ratio Pre HVXE	100	100	99	91	84	79	65	55
—△— Yield of Post HVXE			67.7	75.3	75.6	75.6	76.2	76.5
—○— Yield of Pre HVXE	84.3	85.3	84.7	84.0	84.0	83.9	84.2	83.3
—□— Cum Yield	84.3	85.3	84.6	[illegible]	82.6	82.2	81.4	80.3

Figure 3.14 Electric Test yield of Cheetah18 Rhods product; yield was degraded on post HVXE wafer sequence compared to pre HVXE

Parametric performance was compared between HVXD (pre) and HVXE (post), resulted 9% yield difference as shown in figure 3.15.



20 - 27 DEC Data

	HVXE	HVXD	DIFF
OUNT	80683	633730	
T_YLD	75.818	84.925	9.108
1_Y	5.451	4.581	-0.870
FA_Y	95.961	97.637	1.676
AG_Y	89.251	92.079	2.829
EF_Y	92.863	94.990	2.126
OF_Y	99.632	99.517	-0.115
VW_Y	99.427	99.517	0.090
DW_Y	99.220	99.351	0.131
RW_Y	99.515	99.258	-0.257
W50_Y	99.715	99.605	-0.110
FA_M	1046.103	1083.960	37.857
AG_M	16.234	16.610	0.376
EF_M	-8.269	-8.389	-0.121
OF_M	-14.637	-14.536	0.102
VW_M	-32.603	-32.111	0.492
DW_M	70.619	72.273	1.654
W50_M	11.767	11.847	0.080
RW_M	98.061	98.506	0.445
FA_S	127.811	124.716	-3.097
AG_S	4.777	4.259	-0.518
EF_S	0.772	0.694	-0.077
OF_S	5.549	5.436	-0.112
VW_S	1.673	1.631	-0.042
DW_S	7.087	8.067	0.980
W50_S	1.877	32.129	30.251

Figure 3.15 Yield and parametric performance compared between HVXD (pre) and HVXE (post), resulted 9% yield difference

Yield by wafer sequence is therefore plotted in figure 3.18. It showed yield degradation in the range of wafer HVXE00 - HVXEGW.

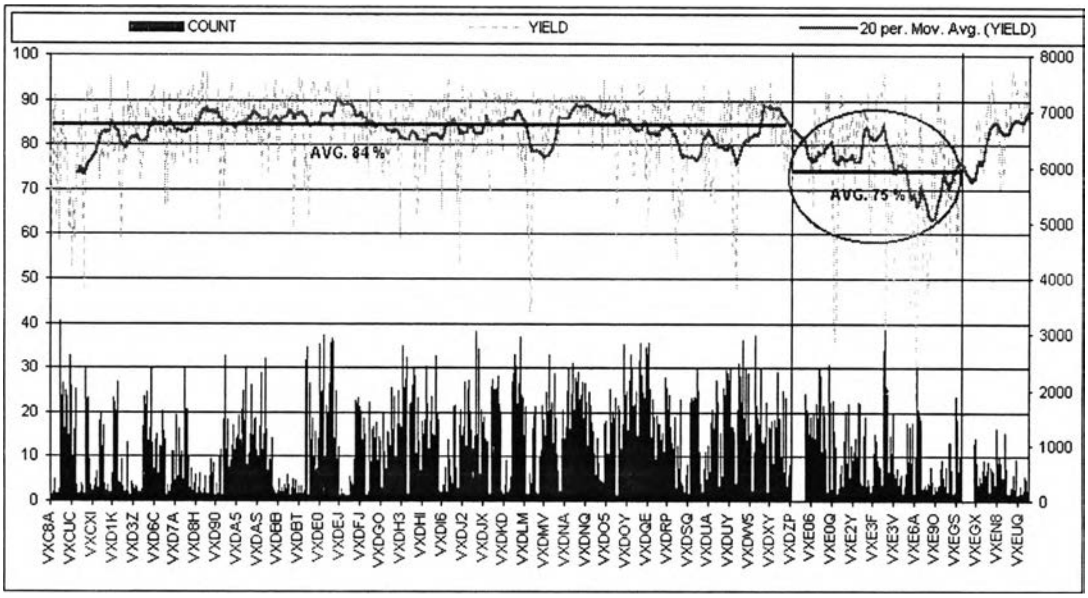


Figure 3.16 Yield by wafer quad sequence; worst yield at the range of HVXE00 - HVXEGW

2) Internal Structure Analysis:

All data analysis performed but did not observed the changes. Failures were therefore submitted to verify internal structure that found internal crack at the area B shown in figure 3.17.

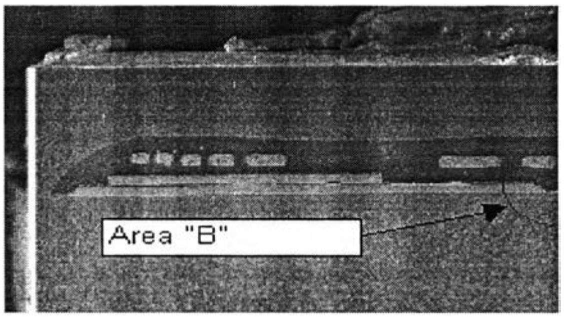


Figure 3.17 Internal structure of slider, found separation at area B due to wafer process fabrication affected to HGA performance

3.2.2.5 Measurement

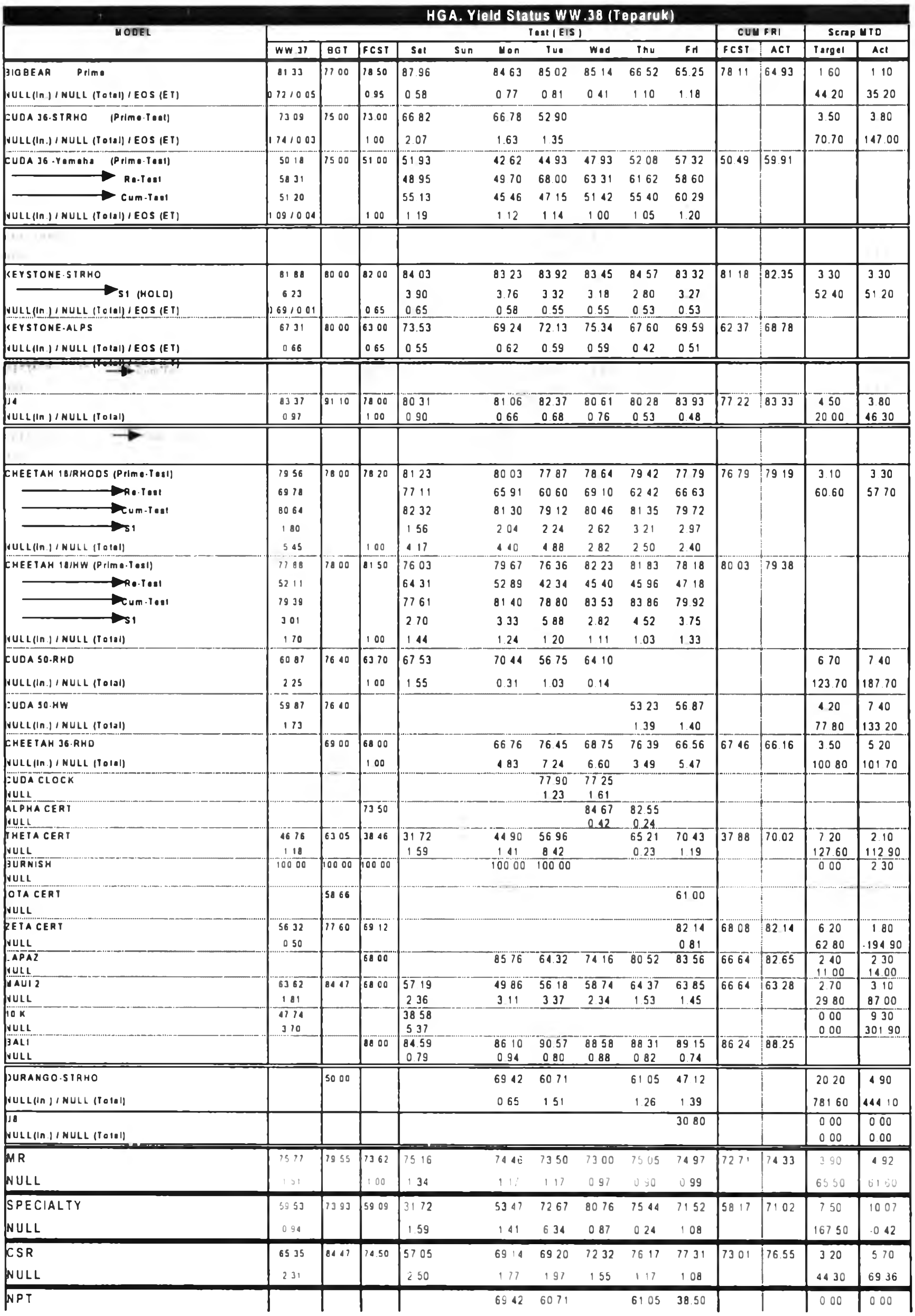
The importance of measurement is that the performance measures must support manufacturing and reflect operational objective measures i.e. operating cost per unit, scrap cost per unit and scheduling.

There are several metrics in measuring performance. However, yield is used in measuring quality aspect of HGA performance. It is the ratio of passed HGA from electrical test operation from total input quantity as shown in equation (1).

$$\text{Yield} = (\text{Total passed HGA} / \text{Total input}) \times 100 \quad (1)$$

Yield is most likely used in detecting and investigating changes occur on variables from raw material, processes, testers and environment which are very complicated to product sensitivity. Therefore, yield is used in analysis of change determination.

As shown in figure 3.18 is the yield report discussed daily and weekly basis in the management meeting.



HGA. Yield Status WW.38 (Teparuk)

MODEL	Test (EIS)										CUM FRI		Scrap MTD	
	WW 37	BGT	FCST	Sat	Sun	Mon	Tue	Wed	Thu	Fri	FCST	ACT	Target	Act
BIGBEAR Prime	81.33	77.00	78.50	87.96		84.63	85.02	85.14	66.52	65.25	78.11	64.93	1.60	1.10
NULL(In.) / NULL (Total) / EOS (ET)	0.72 / 0.05		0.95	0.58		0.77	0.81	0.41	1.10	1.18			44.20	35.20
CUDA 36-STRHO (Prime-Test)	73.09	75.00	73.00	66.82		66.78	52.90						3.50	3.80
NULL(In.) / NULL (Total) / EOS (ET)	1.74 / 0.03		1.00	2.07		1.63	1.35						70.70	147.00
CUDA 36 -Yamaha (Prime-Test)	50.18	75.00	51.00	51.93		42.62	44.93	47.93	52.08	57.32	50.49	59.91		
→ Re-Test	58.31			48.95		49.70	68.00	63.31	61.62	58.60				
→ Cum-Test	51.20			55.13		45.46	47.15	51.42	55.40	60.29				
NULL(In.) / NULL (Total) / EOS (ET)	1.09 / 0.04		1.00	1.19		1.12	1.14	1.00	1.05	1.20				
KEYSTONE-STRHO	81.88	80.00	82.00	84.03		83.23	83.92	83.45	84.57	83.32	81.18	82.35	3.30	3.30
→ S1 (HOLD)	6.23			3.90		3.76	3.32	3.18	2.80	3.27			52.40	51.20
NULL(In.) / NULL (Total) / EOS (ET)	0.69 / 0.01		0.65	0.65		0.58	0.55	0.55	0.53	0.53				
KEYSTONE-ALPS	67.31	80.00	63.00	73.53		69.24	72.13	75.34	67.60	69.59	62.37	68.78		
NULL(In.) / NULL (Total) / EOS (ET)	0.66		0.65	0.55		0.62	0.59	0.59	0.42	0.51				
J4	83.37	91.10	78.00	80.31		81.06	82.37	80.61	80.28	83.93	77.22	83.33	4.50	3.80
NULL(In.) / NULL (Total)	0.97		1.00	0.90		0.66	0.68	0.76	0.53	0.48			20.00	46.30
CHEETAH 18/RHODS (Prime-Test)	79.56	78.00	78.20	81.23		80.03	77.87	78.64	79.42	77.79	76.79	79.19	3.10	3.30
→ Re-Test	69.78			77.11		65.91	60.60	69.10	62.42	66.63			60.60	57.70
→ Cum-Test	80.64			82.32		81.30	79.12	80.46	81.35	79.72				
→ S1	1.80			1.56		2.04	2.24	2.62	3.21	2.97				
NULL(In.) / NULL (Total)	5.45		1.00	4.17		4.40	4.88	2.82	2.50	2.40				
CHEETAH 18/HW (Prime-Test)	77.88	78.00	81.50	76.03		79.67	76.36	82.23	81.83	78.18	80.03	79.38		
→ Re-Test	52.11			64.31		52.89	42.34	45.40	45.96	47.18				
→ Cum-Test	79.39			77.61		81.40	78.80	83.53	83.86	79.92				
→ S1	3.01			2.70		3.33	5.88	2.82	4.52	3.75				
NULL(In.) / NULL (Total)	1.70		1.00	1.44		1.24	1.20	1.11	1.03	1.33				
CUDA 50-RHD	60.87	76.40	63.70	67.53		70.44	56.75	64.10					6.70	7.40
NULL(In.) / NULL (Total)	2.25		1.00	1.55		0.31	1.03	0.14					123.70	187.70
CUDA 50-HW	59.87	76.40							53.23	56.87			4.20	7.40
NULL(In.) / NULL (Total)	1.73								1.39	1.40			77.80	133.20
CHEETAH 36-RHD		69.00	68.00			66.76	76.45	68.75	76.39	66.56	67.46	66.16	3.50	5.20
NULL(In.) / NULL (Total)			1.00			4.83	7.24	6.60	3.49	5.47			100.80	101.70
CUDA CLOCK							77.90	77.25						
NULL							1.23	1.61						
ALPHA CERT			73.50					84.67	82.55					
NULL								0.42	0.24					
THETA CERT	46.76	63.05	38.46	31.72		44.90	56.96		65.21	70.43	37.88	70.02	7.20	2.10
NULL	1.18			1.59		1.41	8.42		0.23	1.19			127.60	112.90
BURNISH	100.00	100.00	100.00			100.00	100.00						0.00	2.30
NULL														
OTA CERT		58.66								61.00				
NULL														
ZETA CERT	56.32	77.60	69.12							82.14	68.08	82.14	6.20	1.80
NULL	0.50									0.81			62.80	-194.90
LAPAZ			68.00			85.76	64.32	74.16	80.52	83.56	66.64	82.65	2.40	2.30
NULL													11.00	14.00
MAUI 2	63.62	84.47	68.00	57.19		49.86	56.18	58.74	64.37	63.85	66.64	63.28	2.70	3.10
NULL	1.81			2.36		3.11	3.37	2.34	1.53	1.45			29.80	87.00
10 K	47.74			38.58									0.00	9.30
NULL	3.70			5.37									0.00	301.90
BALI			88.00	84.59		86.10	90.57	88.58	88.31	89.15	86.24	88.25		
NULL				0.79		0.94	0.80	0.88	0.82	0.74				
DURANGO-STRHO		50.00				69.42	60.71		61.05	47.12			20.20	4.90
NULL(In.) / NULL (Total)						0.65	1.51		1.26	1.39			781.60	444.10
J8										30.80			0.00	0.00
NULL(In.) / NULL (Total)													0.00	0.00
MR	75.77	79.55	73.62	75.16		74.46	73.50	73.00	75.05	74.97	72.71	74.33	3.90	4.92
NULL	1.51		1.00	1.34		1.17	1.17	0.97	0.90	0.99			65.50	61.60
SPECIALTY	59.53	73.93	59.09	31.72		53.47	72.67	80.76	75.44	71.52	58.17	71.02	7.50	10.07
NULL	0.94			1.59		1.41	6.34	0.87	0.24	1.08			167.50	-0.42
CSR	65.35	84.47	74.50	57.05		69.14	69.20	72.32	76.17	77.31	73.01	76.55	3.20	5.70
NULL	2.31			2.50		1.77	1.97	1.55	1.17	1.08			44.30	69.36
NPT						69.42	60.71		61.05	38.50			0.00	0.00

Figure 3.18 Yield report used in output meeting among management daily basis

(Reference: Seagate Thailand Daily Yield Report)

3.3 Workflow Structure

Workflow structure presents the interaction of activity of process engineering, test engineering and quality assurance groups correspond to their responsibility. It describes the user activities, which associate to the models to be developed.

Basically, process engineering framework is to control processes, yield monitoring and analysis, and yield improvement to improve HGA quality. It requires supporting from test engineering group who responds in tester control and tester associates.

Test engineering role is also cover testers built, tester conversion, its spare parts, tester preventive maintenance including standard parts used for controlling testers. Therefore, it resumes all exercises in association with testers including technical development.

Another role of test engineering is playing its role as the supporting group of process engineering, it consequently relates to HGA yield and quality improvement, qualification and implementation.

As shown in figure 3.19, their frameworks that interact each other.

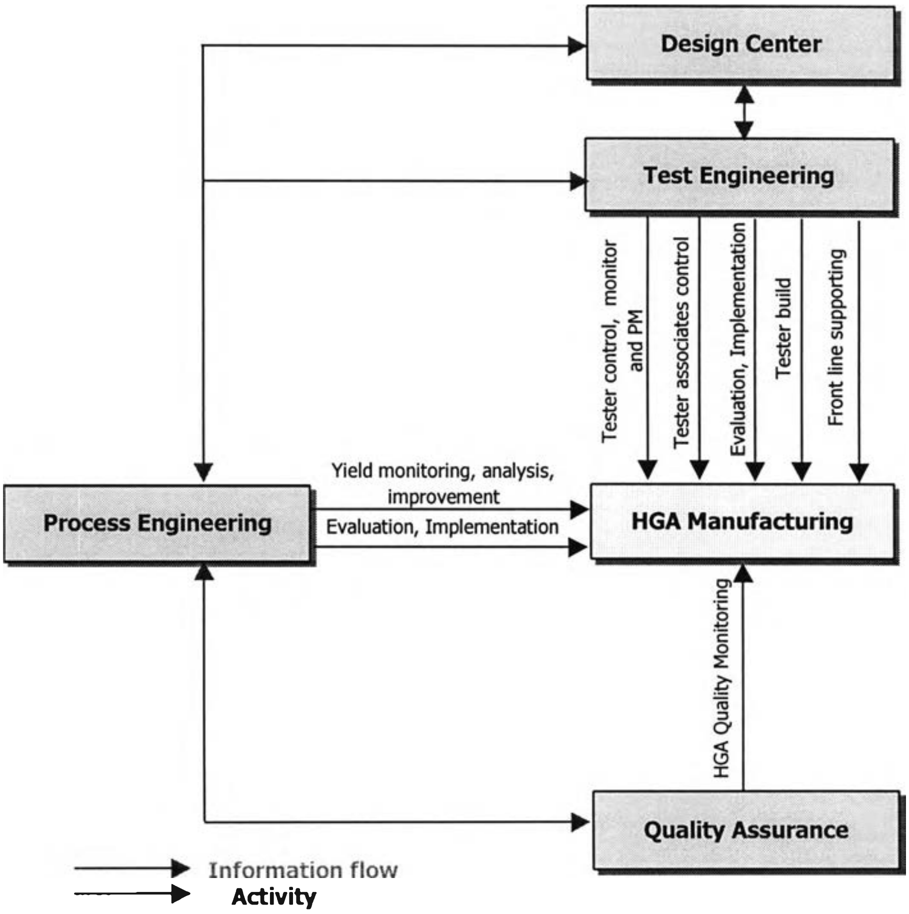


Figure 3.19 Frame work to support HGA manufacturing

3.3.1 Analysis and Communication Flow

With the framework shown in figure 3.19, they are primary activities of people within HGA organization. It is the base for establishing analysis flow shown in figure 3.20 that make the clear communication and work effectively. Besides, it supports yield and product performance improvement and activities based management.

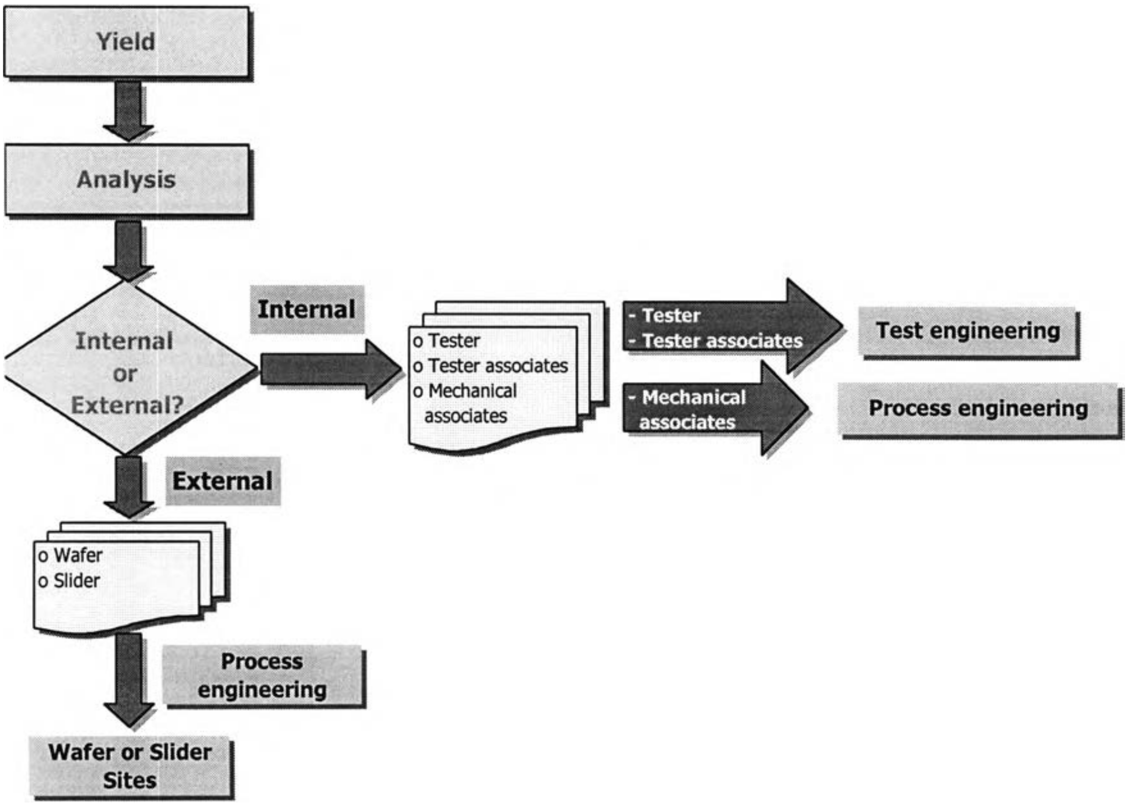


Figure 3.20 Analysis and communication flow

3.3.2 Information Finding

According to the responsibility of each department, it is not simple to find information within limitation of times and several responded activities to do in parallel. Some groups have to assign specific employees to work on this function full time. Some employees spend 50% of their times in finding the required information. Therefore, obtaining accurate and current information from the developed information system make them work easily and communicate more effectively.

The diagram shown figure 3.21 illustrates how they find information currently which query it every time it is needed.

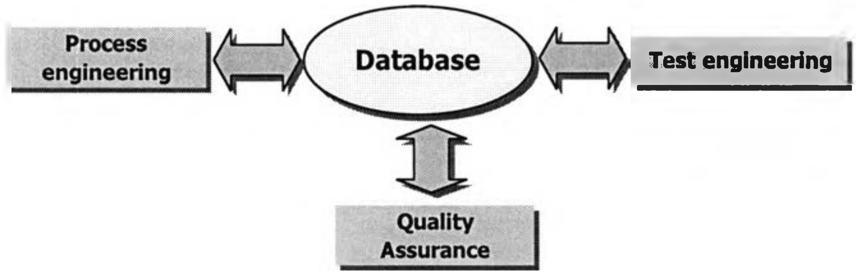


Figure 3.21 Crunching data from database
whenever it is required

3.4 Diagnose Analysis and Procedures in HGA Performance Tests

HGA performance is affected by either internal or external variables as described earlier. Wafers are flowed to HGA operation randomly. The poor wafers screened out at wafer factory are only the continuity circuits defects. They are detected by HGA testing most effectively which is the dynamic test with electromagnetic application performed on rotating disk similar to disk drive working. For, the internal contributors occur in HGA process which is detected at electrical test operation such as contamination, media, HGA mechanical defects, ESD etc, make HGA performed its functions abnormally. The parametric reading may be so poor that it fails specifications.

Cheetah 18 product is an analysis example of HGA test diagnosis.

Its parametric was analyzed on run chart, which is to plot individual HGA by time series sorted. The parameters selected were major defects, which were OVW_AVG and OTC_AVG as shown in figure 3.22

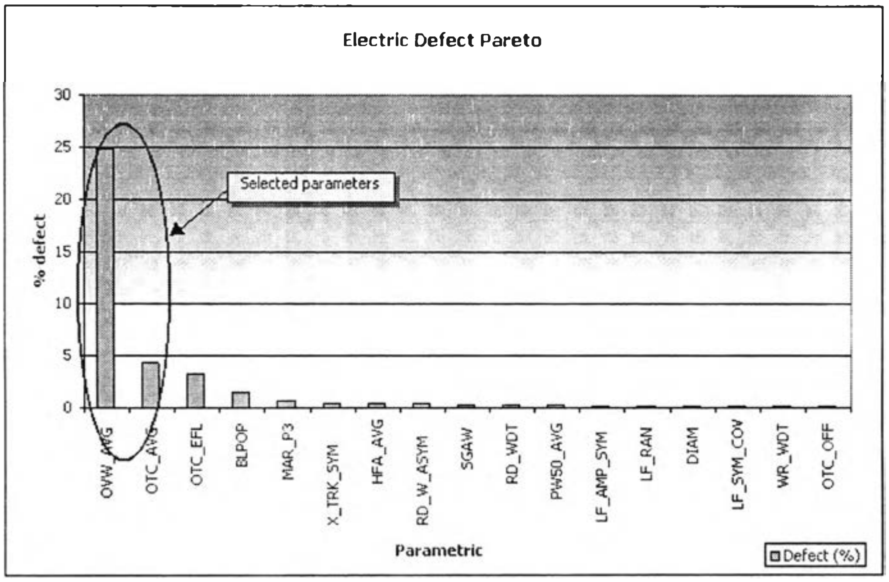
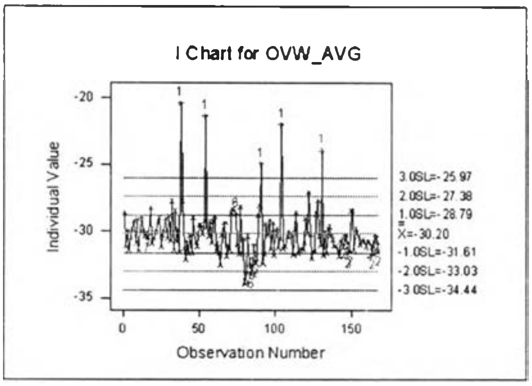
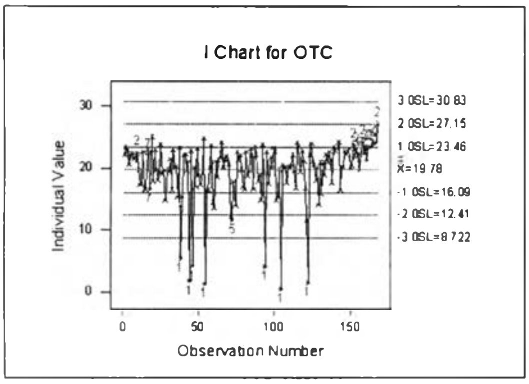


Figure 3.22 Electrical defect pareto of Cheetah18 product

Run chart was then plotted to test its parametric trend to detect the special causes and its stability. As shown in figure 3.23 and 3.24, the charts plotted for 2 hours period of two electric testers out of 14 testers. They illustrated similar trend of both parameters and testers.

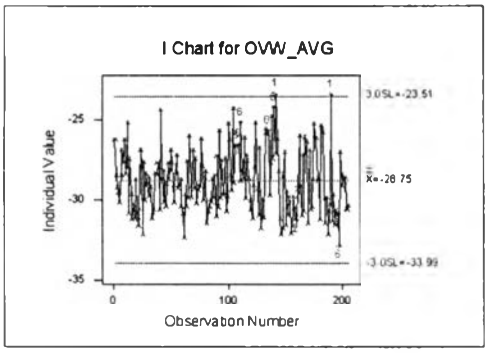


```
TEST 1  One point more than 3.00 sigmas from center line
Test Failed at points  38 54 91 104 131

TEST 2  9 points in a row on same side of center line
Test Failed at points: 86 87 88 145 146 147 148 149 163 164 165 166 167
168

TEST 5  2 out of 3 points more than 2 sigmas from center line
      (on one side of CL)
Test Failed at points  81

TEST 6  4 out of 5 points more than 1 sigma from center line
      (on one side of CL)
Test Failed at points  74 84 85 87 88

TEST 7  15 points within 1 sigma of center line (above and below CL)
Test Failed at points  16 17
```

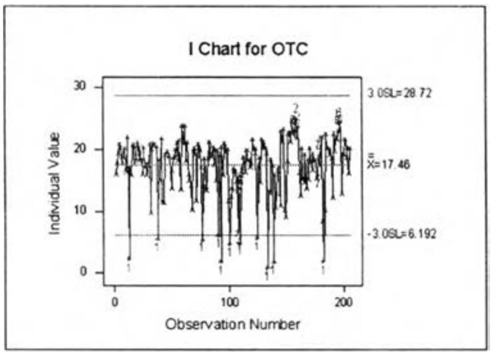


```
TEST 1  One point more than 3.00 sigmas from center line.
Test Failed at points  38 44 46 54 94 104 122

TEST 2  9 points in a row on same side of center line
Test Failed at points  9 10 152 153 154 155 156 157 158 159 160 161 162
163 164 165 166 167 168

TEST 4  14 points in a row alternating up and down
Test Failed at points  38 39

TEST 5  2 out of 3 points more than 2 sigmas from center line
      (on one side of CL)
Test Failed at points: 46 72 122

TEST 6  4 out of 5 points more than 1 sigma from center line
      (on one side of CL)
Test Failed at points: 164 165 166 167 168

TEST 7  15 points within 1 sigma of center line (above and below CL)
Test Failed at points: 17 18
```

Figure 3.23 OVW_AVG and OTC_AVG parameters of tester SGF



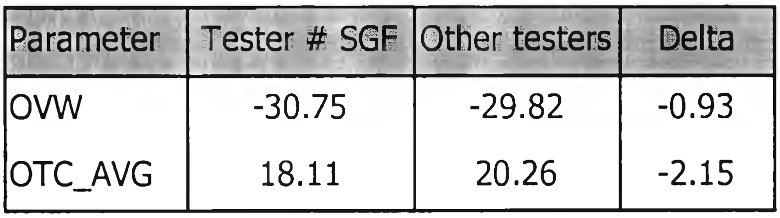
```
OVW
TEST 1  One point more than 3.00 sigmas from center line
Test Failed at points  142 190

TEST 2  9 points in a row on same side of center line
Test Failed at points  158 159 160 161

TEST 5. 2 out of 3 points more than 2 sigmas from center line
      (on one side of CL).
Test Failed at points  140 142

TEST 6. 4 out of 5 points more than 1 sigma from center line
      (on one side of CL)
Test Failed at points  22 108 109 111 135 195 196 197
```



```
OTC
TEST 1  One point more than 3.00 sigmas from center line
Test Failed at points  12 37 76 90 92 100 109 124 133 138 182
          Test Failed at points  22 108 109 111 135 195 196 197
TEST 2  9 points in a row on same side of center line
Test Failed at points  23 107 108 109 110 111 158 159 160

TEST 5. 2 out of 3 points more than 2 sigmas from center line
      (on one side of CL).
Test Failed at points  92 109 182

TEST 6  4 out of 5 points more than 1 sigma from center line
      (on one side of CL)
Test Failed at points  155 156 157 158 159 160 195 196 197

TEST 7  15 points within 1 sigma of center line (above and below CL)
Test Failed at points  177 178 179
```

Figure 3.24 OVW_AVG and OTC_AVG parameters of tester S4F

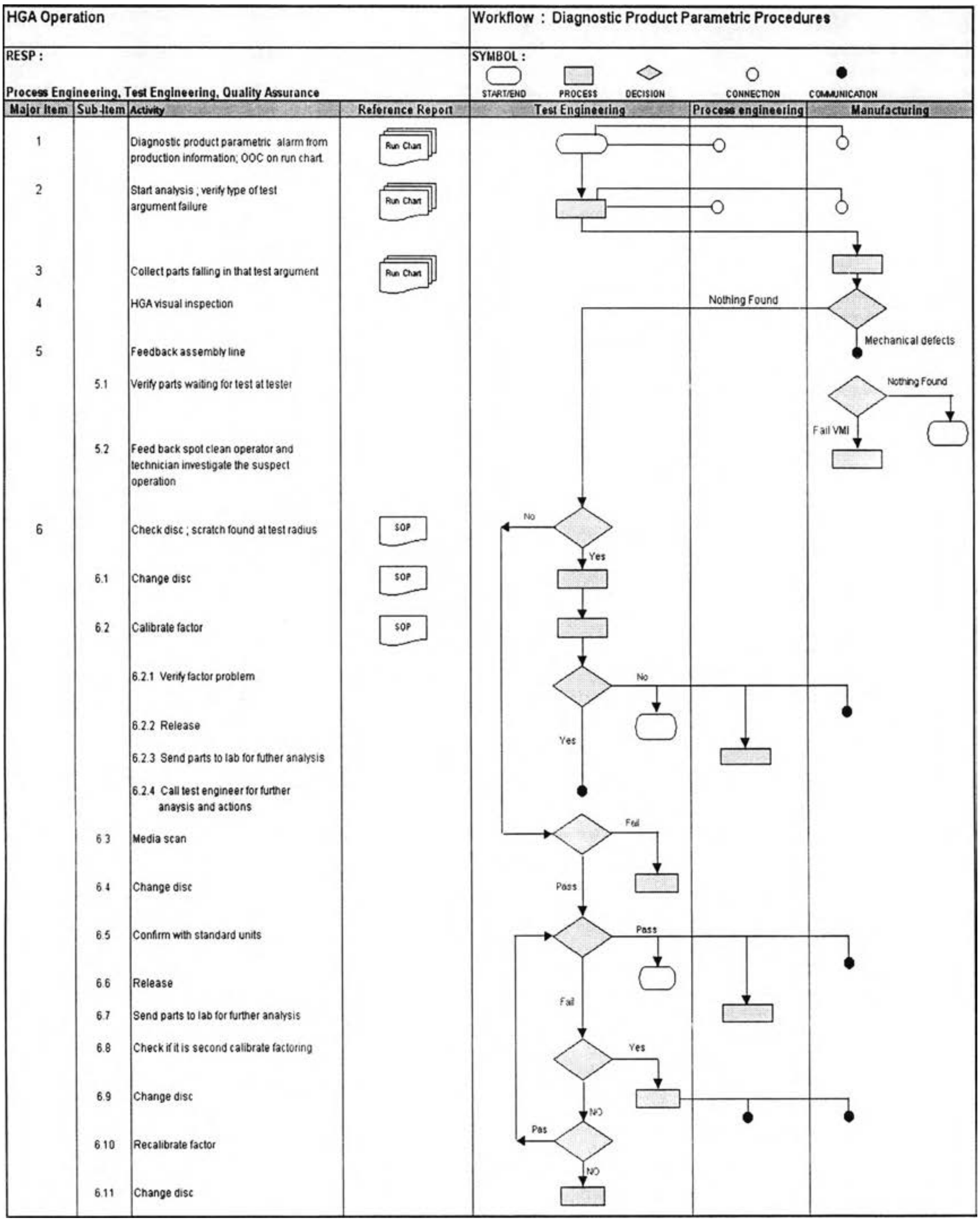
Further analysis to determine the special causes on both testers by investigating the suspected variables by compare with other testers. It was found that all testers using the same lot of disks and standard parts for set up testers. Hence, it may be effects from raw material. HGA built from same bars of sliders and tested on other testers was therefore investigated which found variation within same bars. Wafer process was suspected the effect, which can be confirmed from the HGA physically either external or internal structure. As shown in figure 3.25 same bar comparison between the selected testers and others.



Parameter	Tester # SGF	Other testers	Delta
OVW	-30.75	-29.82	-0.93
OTC_AVG	18.11	20.26	-2.15

Figure 3.25 Same bars comparison between SGF tester, which show high fluctuation of OVW and OTC parameters, with other testers. Bar variation was found (tester problem) is not suspected.

From the above analysis, it indicated effects of special cause that results to instability observed in HGA performance. OOC events occurred highly at 29 times average of both testers and parameters during 2 hours period. Procedures established are therefore proposed to improve its stability by identify the disease from the signs and symptoms as described in figure 3.26.



HGA Operation

Workflow : Diagnostic Product Parametric Procedures

RESP :

Process Engineering, Test Engineering, Quality Assurance

Major Item	Sub-Item	Activity	Reference Report
1		Diagnostic product parametric alarm from production information; OOC on run chart	Run Chart
2		Start analysis ; verify type of test argument failure	Run Chart
3		Collect parts falling in that test argument	Run Chart
4		HGA visual inspection	
5		Feedback assembly line	
	5.1	Verify parts waiting for test at tester	
	5.2	Feed back spot clean operator and technician investigate the suspect operation	
6		Check disc ; scratch found at test radius	SOP
	6.1	Change disc	SOP
	6.2	Calibrate factor	SOP
		6.2.1 Verify factor problem	
		6.2.2 Release	
		6.2.3 Send parts to lab for futher analysis	
		6.2.4 Call test engineer for further anaysis and actions	
	6.3	Media scan	
	6.4	Change disc	
	6.5	Confirm with standard units	
	6.6	Release	
	6.7	Send parts to lab for further analysis	
	6.8	Check if it is second calibrate factoring	
	6.9	Change disc	
	6.10	Recalibrate factor	
	6.11	Change disc	

Figure 3.26 Workflow diagram to investigate special causes

Moving average method can be used in calculating yield to trigger the special cause that affects to yield below target for real-time action as shown below. The range of time t in the calculation is recommended at 60 units, which is the average of units per hour of electric tester. Therefore, every 60 units of HGA tested will be used in calculating yield. With this concept, it also associates with triggering the special cause if find failures fail consecutively. Hence, front line people can take corrective action more real-time.

Yield (%) = (quantity of output / quantity of input) x 100

$$\text{Yield } t = (P_t + P_{t-1} + P_{t-2} + \ldots + P_{t-n-1}) / (D_t + D_{t-1} + D_{t-2} + \ldots + D_{t-n-1}) * 100$$

WHERE ;

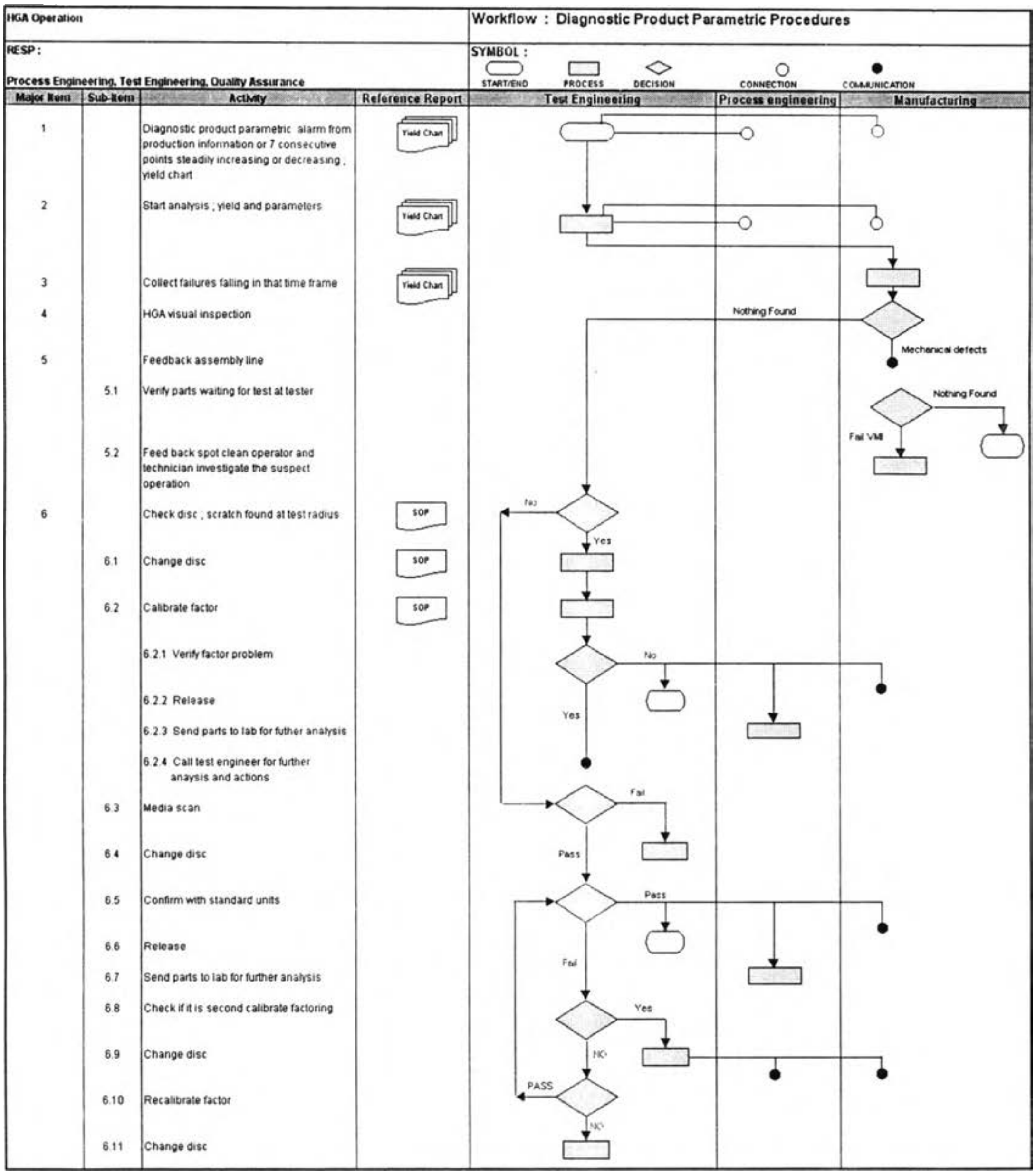
P_t = Passed HGA at time t ; not count for failure
D_t = HGA test in at time t

Another common test that can be made on run charts to detect systematic changes is a run of 7 points as follows:

According to Mark [10]:

> "A run of 7 or more intervals is steadily increasing or decreasing without reversals in direction. Such a pattern is not likely to occur by chance, thereby indicating something needs to be investigated."

Consequently, the workflow diagram established was shown in figure 3.27, a run of seven-point test is also added. The corrective action is required if yield is lower than target or a run of 7 points detected.



HGA Operation

RESP :

Process Engineering, Test Engineering, Quality Assurance

Major Item	Sub-Item	Activity	Reference Report
1		Diagnostic product parametric alarm from production information or 7 consecutive points steadily increasing or decreasing , yield chart	Yield Chart
2		Start analysis ; yield and parameters	Yield Chart
3		Collect failures falling in that time frame	Yield Chart
4		HGA visual inspection	
5		Feedback assembly line	
	5.1	Verify parts waiting for test at tester	
	5.2	Feed back spot clean operator and technician investigate the suspect operation	
6		Check disc ; scratch found at test radius	SOP
	6.1	Change disc	SOP
	6.2	Calibrate factor	SOP
		6.2.1 Verify factor problem	
		6.2.2 Release	
		6.2.3 Send parts to lab for futher analysis	
		6.2.4 Call test engineer for further anaysis and actions	
	6.3	Media scan	
	6.4	Change disc	
	6.5	Confirm with standard units	
	6.6	Release	
	6.7	Send parts to lab for further analysis	
	6.8	Check if it is second calibrate factoring	
	6.9	Change disc	
	6.10	Recalibrate factor	
	6.11	Change disc	

Figure 3.27 Workflow diagram to take action of low yield

For the moving average method, its benefit is to take action real-time. But, it is not put in place because of the management direction requiring to trace back the event occurs in that period of time. Hence, the period of time is implemented in HGA operation. Triggering at 2 hours is used accordingly which also allows more quantity of HGA tested in. The advantage of increasing HGA number is to examine the history performance of same quads tested.