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QUALITY IMPROVEMENT OF THE NEW CELL HSA IN DISC DRIVE MANUFACTURING

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วิทยานิพนธ์ฉบับนี้เสนอการทำวิจัยในหัวข้อการพัฒนาคุณภาพของชิ้นส่วนเอชเอสเอในการประกอบฮาร์ดดิสก์โดยเลือกทำการศึกษาบริษัทซีเกทเทคโนโลยีประเทศไทยจำกัด ในกรณีศึกษานี้ได้เลือกทำการศึกษารูปแบบผลิตภัณฑ์ใหม่ในผลิตภัณฑ์ U2 โดยใช้แนวความคิดเซลใหม่ในการที่จะพัฒนาระบบควบคุมคุณภาพเพื่อเป็นบรรทัดฐานของระบบควบคุมคุณภาพ รวมทั้งการนำ FMEA ,แผนผังการแสดงเหตุและผล , พาเรโต และหลักทางสถิติ นำมาใช้เพื่อกำหนดหนทางการแก้ไขปัญหาในการประยุกต์ใช้กับผลิตภัณฑ์ใหม่ ๆ ต่อไป

แนวความคิดเซลใหม่โดยการนำระบบพัฒนาคุณภาพและเครื่องมือในการควบคุมคุณภาพนำมาปฏิบัติเพื่อเป็นแนวทางในการสืบสวนหาข้อบกพร่อง ส่วนแรกจะกำหนดแผนการควบคุมการผลิต กำหนดมาตรการในการแก้ปัญหาและควบคุมให้มาตรการขจัดปัญหามีประสิทธิภาพส่วนที่สองคือการนำแผนการควบคุมทางสถิติมาใช้การควบคุมของเสียให้อยู่ภายใต้ข้อกำหนด รวมทั้งกำหนดแนวทางและขบวนการแก้ไขปัญหา ส่วนที่สามคือการทำงานเป็นกลุ่ม การฝึกอบรมพนักงาน ส่วนที่สี่คือ การกำหนดเป้าหมายในการทำงานและการพัฒนาคุณภาพ และสร้างความเข้าใจให้กับพนักงานปฏิบัติงาน

ผลจากการทำวิจัยพบว่า สัดส่วนของเสียที่ตรวจพบในส่วนของการตรวจสอบขั้นสุดท้ายมีการปรับปรุงและลดลงอย่างต่อเนื่อง จาก 4100 DPPM ในช่วงไตรมาสที่ 4 (เมษายน – มิถุนายน 2542) และ 600 DPPM ในเดือนกันยายน จนกระทั่งเป็น 124 DPPM ในเดือนพฤศจิกายน โดยมีปัจจัยหลักที่นำไปสู่ความสำเร็จ คือ การกำหนดแผนควบคุมขบวนการผลิตอย่างมีประสิทธิภาพ การทำงานเป็นกลุ่ม การสนับสนุนจากผู้บริหารระดับสูง และการแก้ปัญหาอย่างมีประสิทธิภาพและทันเวลา

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

ภาควิชา วิศวกรรมระบบการผลิต ลายมือชื่อนิสิต .....

สาขาวิชา การจัดการทางวิศวกรรม ลายมือชื่ออาจารย์ที่ปรึกษา .....

ปีการศึกษา 2542 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....

397 29674 21 : MAJOR ENGINEERING MANAGEMENT

KEY WORD : QUALITY IMPROVEMENT OF THE NEW CELL HSA IN DISC DRIVE MANUFACTURING
SHUSAK RATTANASASIVIMON : QUALITY IMPROVEMENT OF THE NEW CELL HSA IN DISC DRIVE MANUFACTURING. THESIS ADVISOR: ASSIST. PROF. DAMRONG THAWESAENGSKULTHAI. 88 pp. ISBN 974-332-802-5.

This study has been performed on the head stack assembly in the disc drive manufacturing. The study aims to improve the quality of head stack assembly (U2 product) at Seagate Technology Company by developing the process control program in the new cell. Quality tools and techniques are used to study such as FMEA, Fishbone diagram, Pareto, and statistical techniques. The closed loop feedback and fast corrective action taken has been established.

The implementation is first to develop the process control plan "PCP". The following part is to set up the triggering mechanisms and corrective action flow. The third part is training to all members in the team including the operators. The fourth part is set up the cell goal and rule to let every one in the team understood the concept and cell target.

From the results of study; The final product audit (Dppm) shows significantly improvement. Defect part per million (Dppm) of U2 product was reduced from 4,100 Dppm in Q4 (April-June'98) to be 600 Dppm and 124 Dppm in September'98 and November'98 respectively. The key factors to achieve are, effective process control implemented, team working, management supporting, and real time corrective action taken. Standardized process control plan was initiated.

ภาควิชา วิศวกรรมระบบการผลิต ลายมือชื่อนิสิต .....

สาขาวิชา การจัดการทางวิศวกรรม ลายมือชื่ออาจารย์ที่ปรึกษา .....

ปีการศึกษา 2542 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....

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ABBREVIATION

PCP	=	Process Control plan
UCL	=	Upper Control limit
LCL	=	Lower Control limit
FMEA	=	Failure Mode and Effect Analysis
QA	=	Quality Assurance
QE	=	Quality Engineering
PE	=	Process Engineering
Prod Supv	=	Production Supervisor
ME	=	Maintenance Engineer
QC	=	Quality Control
SPC	=	Statiscal Process Control
Dppm	=	Defect Part Per million
FPA	=	Final Product Audit

Chapter I

Introduction

1.1 Background :

Seagate Technology is the data information technology company that provides products for storing ,managing, and accessing digital information on the world's computer and data communications systems. Seagate granted in 1997, at Scott valley, California USA. The company is among the 500 largest industrial corporations in the world. Seagate is the largest independent disc drive & recording company in the world. There are 100,000 employees around the multi-plants located around the world. In Thailand, there are Six plants, Teparuk (Samutprakarn), Wellgrow (Chacheongsoa), Chokchai (Pratumtanee), Latkrabang (Bangkok), Rungsit (Pratuntanee), and Korat (Nakornrajchasrima). Totality is about 35,000 employees in Thailand.

The disc drive industry is intensely competitive with manufactures competing for a limited number of major customers. The principal competitive factors in disc drive manufacturing include product quality, reliability, capacity storage, price per unit, product performance, and responsiveness to customers.

Seagate is committed to provide the world with the high quality, highly reliable and competitively- priced disc drives. Our mission is to be committed to total customer satisfaction, to continue improving product quality and to continue offering innovative products. To achieve that target, a good quality system and continuous quality improvement of quality are required for Seagate and should be applied to all plants.

In the viewpoint of customers, the criteria to buy a product is not only good price but also quality of product in order to meet their expectations. Quality, as a term, has different meanings for different people. The most usual meaning from given by the expert of quality can be summarized as follows,

Fitness for use: Refer to the degree to which specific product or service satisfies the want of specific user.

Grade: The degree to which a class or category of product satisfies for people in general.

Quality of conformance: The degree to which a specific product conforms to a design or specification.

Quality characteristic: Any distinguishing feature of grade or a product.

The word quality has multiple meanings. Two of those meanings dominate the use of the word:

1. Quality consists of those product features which meet the needs of customers and thereby provide product satisfaction.
2. Quality consists of freedom from deficiencies.

To explain these dominant meanings it is first necessary to define the key words.

Product : "Product" is the output of any process. It consists mainly of goods, software, and services. "Goods are physical things: pencils, color television sets, office buildings. "Software" has more than one meaning. A major meaning is instruction programs for computers. Another major meaning is information generally: reports, plans, instructions, advice, commands. "Service" is work performed for someone else. Entire industries are established to provide services informed for someone else. Entire industries are established o provide services in such forms as central energy, transportation, communication, entertainment, etc.

Product Feature: A "product feature" is a property which is possessed by a product and which is intended to meet certain customers' needs. Product features may be technological in nature, e.g. fuel consumption of a vehicle, dimension of a mechanical component, viscosity of a chemical, uniformity of the voltage of an electric power supply. Product features may also take other forms, e.g., promptness of delivery, ease of maintenance ,courtesy of service.

Hierarchy of Product features: Products exits in a sort of hierarchical or pyramidal organization. At the apex is the overall product or system. Below the apex are multiple layers made up of subsystems, components, etc. At each layer the products have features which must be defined by specifications and procedures. In the bottom layer are numerous bits of the whole, e.g., tasks in a procedure, properties of materials or piece parts.

For such tasks or properties, the product features consist of elemental definitions, e.g., the temperature of the oven, the diameter of the shaft. Such product features are often referred to as " Quality characteristic"

Customer: A customer is someone who is impacted by the product. Customers may be external or internal.

External Customer: These are impacted by the product but are not members of the company (or other institution) which produces the product. External customer include clients who buy the product, government regulatory bodies, the public (which may be impacted because of unsafe products or damage to the environment), etc.

Internal Customers: Within any company there are numerous situations in which departments and persons supply products to each other. The recipients are often called "customers" despite the fact that they are not customers in the dictionary sense, i.e., they are not clients.

Users: Users are customers who carry out positive actions with respect to the product. Users include processors who buy the product as an input to their process, merchants who resale the product, and consumers who carry out the ultimate use of the product.

Customer Needs: All customers have needs to be met, and the product features should be responsive to those needs. This applies to both external and internal customers. In the case of external customer, the response determines product satisfaction, and in consequence, product satiability. In the case of internal customers, the response determines the company's competitiveness in productivity, quality, etc., as well as the state of morale among internal departments.

Product Satisfaction: Product features which do respond to customer needs are said to provide "product satisfaction," a state of affairs which is decisive as to satiability of the product. In competitive markets there are multiple supplier of product features. The resulting variation leads to degrees of product satisfaction, and to associated differences in market share for the respective supplier.

However, to be successful in the business, a company should be focused on how to produce high quality at lower cost.

1.2 Problem areas

This study is concerned with quality improvement efforts in the head stack assembly process which is the one of the sub-assembly components in the disc drive. In head stack assemblies product quality is affected by reliability and quality of the raw material, process tools and equipment and manufacturing process from raw material to final finished units. In fact, quality control related actions can be performed to deliver high quality products during production to meet the needs of customers. The nature of production process in head stack assembly is characterized by.

1. Mass continuous production environment.
2. Manual assembly line
3. Line/cells manufacturing process.

Below are the current cell layout of head stack assemblies compared with the new line (cell). The current lay-out is difficult to control and is susceptible flow errors while the new purpose flow will be more easily controlled.

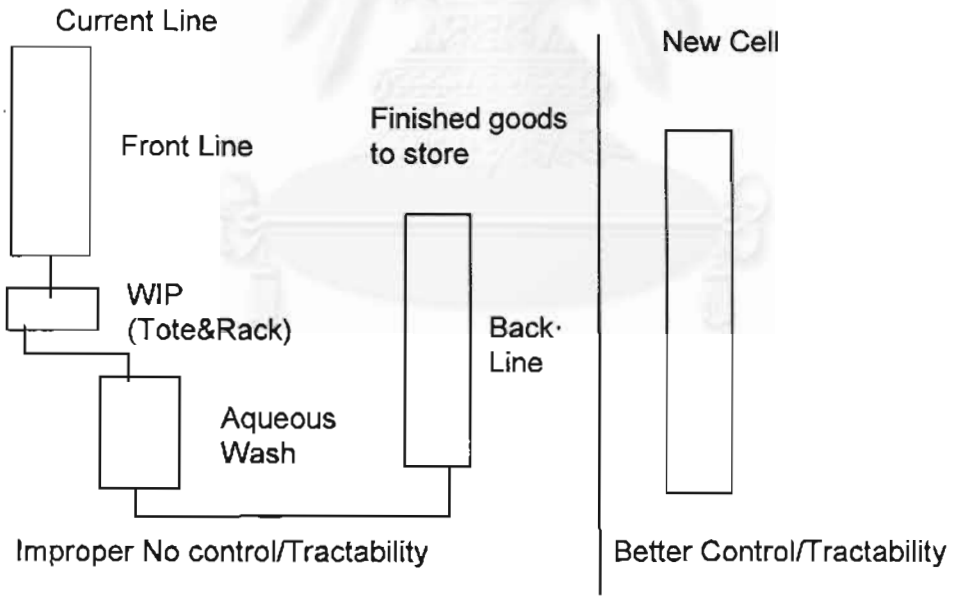


Figure 1.1 : Current lay-out of U2 HSAs compare with new cell

Furthermore, the nature of the product is characterized by complex assembly, the need for high quality and reliability, and process control is not appropriate to keep changing frequently. This situation lead to problems, i.e.

Dppm at out going gate (FPA) does not meet the target; the Dppm at out going gate is target at 1 K Dppm (max). The major defectives can be summarized af follow,

- Solder defects
- Swage deffects
- Bent flexure/ gimbal
- Others.

Coping with the problems, the effective process control in the head stack assembly line is required for study in order to provide solutions. This study will be focused on designing the HSA process control plan. Tools and techniques such as; FMEA, SPC, quality tools, Sampling plan technique, and process triggers will be used as appropriate, together with implementing quality ownership concepts in each cell.

1.3 Objectives of the study

- To improve the quality of HSA "head stack assemblies".
- To establish an improved and standardized quality control program in the U2 HSA "head stack assembly process".

1.4 Scope of the study

1. The study will focus on the head stack assembly process at Wellgrow plant. The product selected for study is U2. This product is a new models with will become the high volume build in the future.

2. This study aims to improve the quality of head stack assembly by developing the standard process control programs as appropriate. The major focus are; line monitoring (material VS process); Closed loop feedback (signal alerting, customer traceability, etc); Cpk, R&R, etc; Line

qualification; contamination control; system level audits (ESD, Temp/RH, DI, etc.)

3. Methodology; The data will be collected and analyzed by using QC tools such as, Pareto and trends for each defect, SPC, Cause and effect diagram, and/or the FMEA technique as appropriate.

4. The primary measurement point will be the out going gate or final product audit gate which measured in Dppm and will be presented before and after comparisons.

The U2 model process assembly flow was described below.

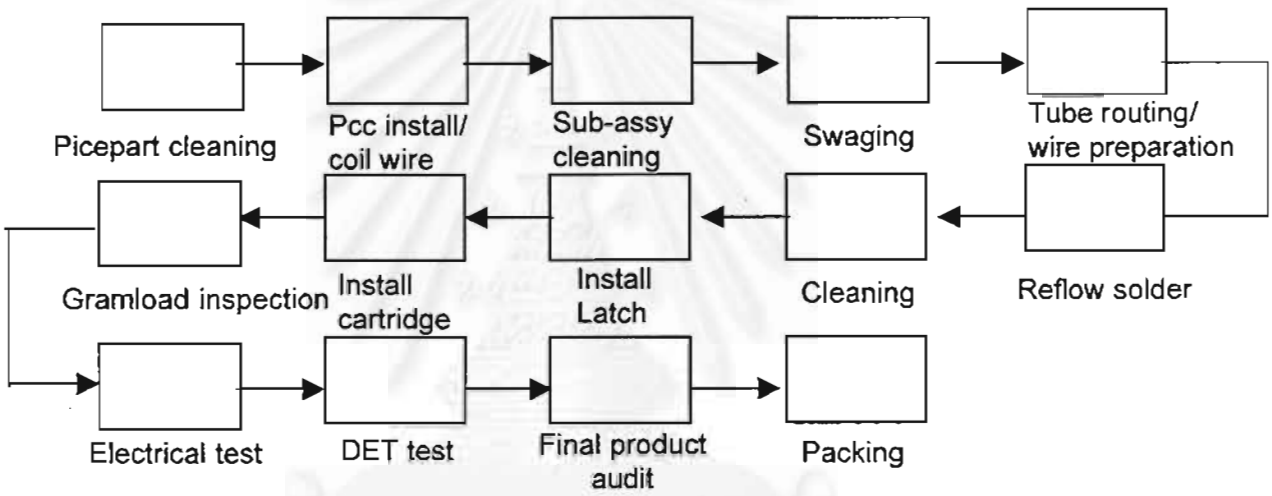


Figure 1.2 : U2 Process Flow

1.5 Benefit of the study

- Single line lay-out for better process flow. (Increased capacity)
- Real time triggering system for fast feedback and problem solving.
- Better out going quality
- Improved production yield.
- Reduce from customer complaints.

Chapter ii

Literature review and methodology

2.1 Literature review

- **Theerawadee Plienmolee ; Failure Mode And Effect Analysis (FMEA) Implementation. AIT**

  Failure Mode and Effect Analysis (FMEA), A DFM methodology of concurrent engineering, can be used to effectively increase process yield and reduce cycle time. FMEA is an enginnering tool used to define, identify, and eliminate known and/ or potential modes of failures in a product. In fact, FMEA is a methodology to evaluate the system, design, process, or service associated with delivery of a product to customers for possible ways in which failure can occure.

  This thesis presents an application of FMEA to an integrated – curcuit assembly factory. As most product failures in this type of this assembly occure due to design and process problems, the factory's current procedures in design and process FMEAs are analyzed for improvements. Implementation of the improve design and process FMEA procedures resulted in increased process yields and reduce defect rates.

- **May Chumar Kyi ; An integrated MRP-II and quality system. AIT**

  Simulation model has been developed to represent the Statistical Process Control sub-system of a manufacturing system and output (scrap rate) from the simulation model is loaded into the interface. By using the available information from the statistical process control.

- **Thiti Boonyanukhroh ; Quality improvement of body fuction in automotive assembly plant. Chulalongkorn**

The task was to establish working standards and the new reporting to correct the defects. Quality performance measurement was conducted to identify the perticular departments. In conclusion, he found that the quality control in the technical department should be improved, as follow.

1. The key point standard of electrode must be 5 mm. Diameter of upper Electrode, 6 mm. Diameter of lower electrode, 7 mm. Gap between upper and lower electrodes, 400 +/- 20 degree C. tip temperture.

2. It was found that the amount of defect lots decreased from 153 to 92 lots during the six months period.

- **Prasert Kunapis ; Quality control system development for small – arms ammunition process. Chulalongkorn**

The main objective of this study is to improve quality control system of the small –arms ammunition process since the present process showed high rate of defectives. The procedure of study started from data collection and analysis of the present work system. By employing "parato Diagram" the major problems including the source of problems were identified. The improve "inspection and test plan" was develop and tried- out based on quality control techniques.

The result of the trial use of the "inspection and test plan" showed that the most critical problem occurred at the operation "final cutting of the tube" by using critical analysis into the problem was solved by recalibration of the equipment. It resulted in the improvement of process capability (Cp) from Cp= 0.729927 to Cp=1.291489 which was very close to the standard value.

Based on the findings of the study it lends to the conclusion that the improved "inspection and test plan" developed by this study had contributed to the substantial improvement of the quality control of the small-arms ammunition if it will be seriously implemented.

- **Jakkrawarn Kunadilok ; Quality control system development for the food can industry. Chulalongkorn**

The main objective of this study is to re- organize the quality control scheme in the food can industry and to improve its production process for lost reduction. The case study is the factory producing lacquer coated sheet, can and cover.

The study focuses on the improvement of the quality control in the production process and the inspection of the final product. Such improvement are divided into three step production process improvement , process quality control improvement and final product inspection improvement. To improve the effectiveness of the designed improvement programs, all operator involving in such process have to be well- trained before working following the procedures assigned in this programs.

The results after implemented showed the defective of all product study were reduced. The conclusion from the study is the improvement of the quality control in the production process and the inspection of the final product is applicable to improve the quality of other food can industries.

- **Niwat Pradubwong ; Improvement of quality control system in puch & dies for small arms ammunition manufacturing process. Chulalongkorn**

The quality of punch & dies is important factor on quality of ammunition case. The aim of thesis is to improve the quality control

system in punch & dies for small arm ammunition manufacturing process. The focus point of the study are,

1. Proposed reorganization of quality department and sset up job description of each personal.
2. Improved the process of incoming raw material inspection by initiating inspection procedure and supplier/ vendor evaluation.
3. Improved inprocess quality control.
4. Improved finished product inspection.
5. Set up quality records which was parallel with the improved quality control system.

The result of implementation was significantly presented by decreased number of defected example group (punch & dies). The quantity of example group was decreased about 33.33 %.

- **Chatchawan Temridtiwong ; Design of quality control plan for serial production system. AIT**

The transformation of materials into a finished product normally uses several production stages. The common practice is to inspect the incoming lots first for some quality conformance and then to perform production operation on that lot. Output form each production station before going to the next stage must be inspected again. Because of the reliable factor, this study is issued the rectifying inspection policy for the incoming raw materials and screening inspection policy for the units so as to optimize global objective that is appraisal costs minimization.

This study is separated work into 2 models. Single line multi-stage series system is contemplated in the model I. A pattern search technique is used to calculate the optimal policy with the specified Average Outgoing Quality Limit (AOQL). Computer program is written for reckoning this model function. Model II is two series line production with commonality. This model observes the effect of commonality on the optimal inspection policy.

- **Anucha Fuang-arom ; Statistical methods for quality improvement in a gypsum board manufacturing process. AIT**

  Quality is an important problem in any gypsum board manufacturing system. This study is concerned with the use of statistical techniques to analyze the quality problem of gypsum board in Siam Fibre-cement Co.,Ltd.

  The existing quality control activities of this company have been studied. A major problem is the uneven surface board caused by the poor quality of paper. So the main objective of the present study is to set the best level of each important paper quality characteristic for producing good quality board.

  The minor objectives of this study are the testing for uniformity in order to measure the consistency of paper quality throughout the roll and the testing for validating of the vendor sample for representing the samples of the company to reduce loss form the existing sampling procedure.

- **Jakrapong Karnjanasomwong ; Development of quality assurance in the recording magnetic head assembly process. Chulalongkorn University**

  Quality Development is studied at recording magnetic head assembly process. The quality program is approached to implement in the recording magnetic head assembly such as Cpk, % R&R and total quality management. The suggestion is provided to further improvement.

2.2 Methodology

2.2.1 Quality Control Systems

Definition of quality: Quality is a judgement by customers or users of a product or service; It is extent to which the customers or users believe the product or service, serve their needs and expectations. A firm's quality improvement efforts theoretically never end. It reduce suppliers, customers, investors, employees, and the community.

System approach and process control: : It is not very easy to approach the new concepts and theories to changes the existing culture that already been there for so many years. Consideration of process improvement will require tracking and measurement of the changes. Statistics control methods applied to the various aspects of a business organization can provide the data that demonstrate the efficiency of the organization as well as the individual processes within the organization. Once the method of sampling is identified, SPC charts can be used to identify those particular points in the organization that are out of control. The process being examined can then have the out of control points worked individually and brought into control. The keys of an efficient system of process control are communication, commitment, visibility, speed, and simplicity.

The team participation in the process improvement is very important. Group work will be more effective to improve the processes they deal with daily. Many good point may brought into discussion at the meeting rather than a revolution of engineering only. The team goal is " Do it right at the first time" does not perform the screening of bad parts at final operations.

The system approach to process control will ensure that improvement is a part of daily routine activities. A team attitude includes the exchage of ideas. Moretime may be needed on identified failure or problem analysis.

Dr. W. Edwards Deming is widely recognized as a teacher of quality management, and is known throughout the world for his " Fourteen Points for Management." The described following are presented.

1. Create a consistancy of purpose for improvement of product and service. A commitment to quality improvement is required. Management must have a long range vision that will ultimately be based on continuous improvement of processes.

2. Adopt the new philossophy. We are in the new economic age. No longer can be accept the delays, mistakes, and defective workmanship that now exist in the work place. Worldwide competition has introduced new competitors and also different means of obtaining a competitive advantage. Customers now expect that the producer will provide the maket with excellence.
3. Cease dependence on mass inspection as the primary method for improving quality. Require instead that statistical evidance be supplied that quality has been buit in. Anything less is costtly and will produce a higher price for the consumer to absorb. Look for the method to accurately obtain the evidance by examining the cause of variation within the processes and striving for process improvement through teamwork and employee participation.
4. End the practice of awarding business on the basic of price tag. Price does not nessary equal cost. And initial low price could easily turn into a higher consumer cost after all costs are considered.
5. Constantly improve the process of production and service. It's management's job to work continually on the system, as well as to find the problem and develop opportunities for their solution. There are only two sources of problems: process and people. Deming say that only 15% percent of quality problems rest with the employees. The rset fault of the process.
6. Integrate modern methods of on-the-job training. Training must center on the job location and correction of process variation; anything less is only a temporary fix. By centering on the correction of variation, it becomes logical to teach the tools of SPC.
7. Develop tailored methods of supervision and management. Strive for quality in supervisory personnel rather than great numbers of micromanagers causing delays in the workplace. Supervision must be by example and demonstration, and must focus on the commitment of the supervisor to improve process control.
8. Drive out fear. Effective work connot be accomplished under fear of derision or punisment. Communication must be encouraged to be a "two way street." Feedback from engineer to engineering manager and from manager to engineer must be accomplished. The basis for continusous process improvement is cooperation and

teamwork at all levels with objectives andincentives shared by both engineer and engineering manager.

9. Break down barriesrs between departments. Feedback, feedback feedback. Communication , communication, communication. When importance is [laced on the interfaces betwwn various departments. Communication is a natural outcome. Barrriers are removed and interdepartmental cooperation occurs.
10. Elimnate slogans, numerical goals ,posters and other pressure-creating devices. Process improvement through employee participation will occur when new levels of efficiency asked for without the method being provided by manageement. Improvementmust be encouraged through the individual engineer.
11. Eliminate procedured that require a specific output from each employee, Instead, concentrate on the formation of a team attitude within the laboratory. Procedures that require a specific numerical output by an workmanship and create an atmosphere of error.
12. Remove the barriers that stand between the engineer and his right to pride in workmanship. When an atmosphere of teamwork is presented and maintained and employee will know just what is expected of him. Communication between work force and management is lept at the maximum and the engineer;s satisfaction with his job is at the highest level.
13. Institute a vigorous program of education and retraining. Enable each employee to funcion within a team of peers. Provide an atmosphere thorugh education that is conducive to maintenance of dignity and satisfaction in the laboratory environment.
14. Encourage every individual within the workplace to dedicate himself to this transfromation. Reward those engineers who supprot the new system, and concentrate on the development of policies that are system oriented. Make haste slowly. Allow the required changes to take place over a long period of time. The best results occur when the new method merely replaces the existing one. The two systems run parallel for some period of time, until the old method just fades away.
(Ref. Module Material . 1997.: Quality and reliability. Regional centre for manufacturing systems engineering and Warwick Manufacturing Group.)

2.2.2 The seven quality tools

If a product is produced to meet the customer's requirement with fitness for use criteria, the operation or process should be repeatabile and stabile. The process should be operated under control in order to minimise of variability around the target or norminal dimensions. Statistical process control (SPC) is a powerful tool and is useful in meeting the process stability and improving capability through the reduction of variability. SPC can be applied to any of processes. Refer to the Juran quality hand book the Quality's seven major tools are summary as follow:

1.Cause-Effect Diagram
2.Defect Concentration Diagram
3.Check cheet
4.Histogram
5.Scatter Diagram
6.Pareto chart
7.Control chart

Cause and Effect Diagram :

Cause and Effect analysis are usually summarized in a cause – effect diagram. This was developed by Ishikava for the purpose of representing the relationship between an defect and the potential or possible causes influencing it. Sometime this called " fish- bone diagram", the effect is typically contained in a box on the right side , while the causes appear on the left side. This tool will help to discover possible root causes of defects and then helps to understand the failure mechanisms and resolving and preventing to the causes. Figure below are the cause and effect diagrams in listing of the possible cause of process, material, tools and workmanship.

Fishbone Diagram:

Normally, this tool will be using when the defect, error, or problem has been identified and isolated for futher study, the next step is to analyze the potential causes of this effect. This tool is widely used in order to analyze the cause that are not obvious case and the problem suitation is not too critical. There are very suitable tools for the front line operators as team working and brianstorming. The steps in constructing the cause and effect diagramare as follows:

- Define the problem or effect to be analyzed.
- Form the team to perform the analysis. Often the team will uncover potential causes through brainstorming.
- Draw the effect box and the center line.
- Specify the major potential cause categories and join them as boxes connected to the center line.
- Identify the possible causes and classify into the categories in step 4. Create new categories, it necessary.
- Rank order the causes to identify those that seem most likely to impact the problem.
- Take corrective action.

Stratification Analysis :

Stratification is the process of breaking down or sorting a large database so that meaningful subsets, classifications , or summaries can be developed. For example, it can be easier to sort the data or fialrue by categories, by defect code, product model, range of serial number that we needed. Stratification allows us to seeking all those information data for analysis.

Check sheet :

A check sheet is a simple tool used to record the data, it can be used to keep monitoring the machine, processes or measurement tool. Check sheets are widely used in every firm, the format can be developed depending on the application or the purposed.

In the stages of the SPC implementation, it is often necessary to collect either historical of current operating data about the process under investigation. A check sheet can be very useful in this data collecting activity.
When designing the check sheet, it is important to clearly specify the type of data to be collected, the part of operation number, the date, the analyst, and any other information useful in diagnosing the cause of poor performance.

Histogram :

The histogram is a graphical data summary tool which help to group data into cells, or categories. This tool is very valuable data analysis tool.

Scatter Diagram :

A scatter diagram provides us the opportunity to view the data set in multiple dimensions in order to detect trends, explore cause-effect relationships, and so on. The scatter diagram is a useful plot for identifying relationship between two variables. Data are collected in pairs on the two variables, the shape of the scatter diagram often indicates what type of relationship may be occurring between the two variables.

Pareto Analysis :

The pareto analysis is to separate the vital few from the trivialmany. This tool canasist us to identify the most important effects and cause and to stratify the available data in order to prioritize our improvement effort. In general, there are two types of Pareto diagrams.1) Result-Category diagrams and 2) Cause-category diagrams. The result diagram refers to defect-categories and the cause diagram refers to defect causes. For instance, a defect-category diagram could be used to identify and highlight the product that has the highest scrap cost while the defect-cause diagram is focused the root cause rank of the scrap causes. There step process in pareto analysis as follow;

- Determine the results or causes to be analyzed and the frequency of the measured. The analysis can be developped over a given study period (e.g. a week, a month).
- Pareto check sheet is used to select and rank the items (results or casues), the total frequency of all items are normally calculated to percentage.
- The data plot pareto table or check sheet summary are a vertical bar graph; the heights of the are correspond to the frequency count on the left axis. The right axis is used to indicate the cumulative percentage.

The Pareto diagram is a prioritizing tool that helps us isolate and focus on the main problems or concerns. It helps to focus on the most critical defects or causes and put effort to resolve the problems. By comparing Pareto diagrams before and after improvement efforts, the results of improvement can be observed.

The Pareto diagram is normally used together with cause and effect analysis in developing corrective action : In general , we use a Pareto analysis to identify a critical problem or opportunity for quality improvement while the cause and effect analysis to identify causes relative to the effect, root cause of problems, the become an instrument for documenting and communicating quality improvement progress.

Process Control Charts :

The control chart is the graphical display of a quality charecteristic that has been meansured or computed from a sample versus the sample number or time. The cahrt contains a center line that represents the average value of the quality charecteristic coresponding to the in control state. The other two lines, called the upper control limit (UCL) and the lower control limit (LCL), were also showed on the chart. As long as the point plot within the control limits, the process is assumed to be in control, and no action is necessary. However, the point that plot outside of the control limits is interpreted as evidance that the process is out of control, and investigation and corrective action is required to find and eliminate the root cause.

The most important use of a control chart is to improve the process. Some generally cases may found as follow;

- Most processes do not operate in a state of statistical control.
- Consequently, the routine use of control charts will identify assignable causes. It this cause can be eliminated from the process, the process will be improve and the variability will be reduced.
- The control chart will only detect assignable causes. Management, operator, and engineering action will usually be necessary to eliminate the assignable cause.

In order to eliminating the assignable causes, it is very important to find the root cause of the problem and attack it. Effective system for corrective action is a key in order to success with the SPC implementation.

- Control chart can be classified into two types. Variable control chart will be
  used if the quality charecteristic can be measured and expressed as a number of measurement. Attribute control chart will be used when we not measure the part as a number but collect them as a unit as conforming and non-conforming. A control chart are idely used in the industrial company, there are many benefit of using this tools as some major described following;
- Control chart are a proven technique for the improving productivity. A successful control chart program will reduce scrap and rework, which are the primary productivity – killers in any operation. When the scrap and rework reduce the productivity and good units will be increases.
- Control charts are effective in defect prevention. The control chart helps keep the process in control, which will serve our requirement as " Do it right at the first time". It the process do not set up to be effective process control, then the non-conforming will be occurred for sure.
- Control charts prevent unnecessary process adjustments. A control chart can distinguish between background noise and abnormal variation.
- Control charts provide diagnostic information. Frequently, the pattern of point on the control chart will contain information of

diagnostic value to an experienced operator or engineer. This information allows the implementation of a change in the process that improves its performance.

- Control charts provide information abhe process capability. The control chart provides information about the value of important process parameters and their stability over time. This allowa an estimate of process capability to be made.

The rules for Control Charts: There are several criteria may be applied to a control chart to determine whether the process is out of control. However, the rule that are widely used in practice are listed below.

- One or more points outside of the control limits.
- A run of at least eight points, where the type of run could be either a run up or down, a run above or below the center line, or a run above or below the median.
- Two of three consecutive point outside the two- sigma warning limits but still inside the control limits.
- Four of five consecutive points beyond the One- sigma limits.
- An unusual or nonrandom pattern in the data.
- One or more points near a worning or control limit.

Finally, as more out of control criteria are applied to the chart, the decision process becomes more complicated, it could be easily to implemented in a computer program.

2.2.3 FMEA " Failure Mode and Effective Analysis": (ref. FMEA procedure. 1997. Seagate technology).

FMEA is primarily a qualitative tool which can support proactive quality strategies. FMEA seeks to identify possible failure modes and mechanisms. FMEA is widely used in quality planning and product design detail, It is a very useful tool in manufacturing process analysis. It is effective in both product and process performance improvement.

FMEA is basically a tabulation of system functions or system equipment items, the failure mode for each, and the effects of the failures on the system

(People, equipment and etc). FMEA identifies single failure modes that can cause, or contribute to the cause of an accedent or nonperformance. FMEA is not useful for identifying combinations of failures that can lead to accidents. FMEA contains eight major columns or entry categories;

1. Functional or equipment identification; It identify specific functions or items to be analyzed.
2. Functional or equipment purpose; It described the fucntion or equipment in enough detail in order to clearly communicate its essence relative to potential failure modes.
3. Failure mode; It is identify all potential failure modes for the associate function or equipment.
4. Failure mechanism; The failure description or failure process of each failure mode must be identified.
5. Failure detection; This refer to the means of identifying a failure in the process of happenning. A tester, workmanship, or gauge, is involved in detection.
6. Failure compensation; This is not always included; it just a document of systems and backup.

Chapter iii

Data analysis

This chapter discusses the background of the product study, data analysis and applications of techniques used to analyze data information in order to investigate the root causes of problems. Fishbone diagram (cause and effect diagram), FMEA and statistical technique are the tools for this study.

The data information for this study were obtained from the following main sources; Dppm (Defect part per million) at Final Product Audit (FPA), quality audit check sheet, daily yield tracking and etc. For this study, Final Product Audit (FPA) is the data to be measured for representing the product performance.

3.1 Background of the product study

The hard disc drive itself is a very complex Electro-mechanical machine. The advance made since the inception of the disc drive in mid 1960s have been incredible. In efforts to store more and more information in the same size "box". New products are developed every day. Remember, a disc drive has only one purpose-to store and retrieve data.

Although a disc drive is complicated, a modern drive has three major sections, the controller, the read/write section, and the positioning section. Each of these section has its own job to perform within the system. Although each section is independent of the other they must work together as a system in order to store and retrieve data.

- Controller – communicates with the host computer and the drive electronics.
- Read-Write – Writes data to the media, reads data from the media.
- Positioning – Positions the read-write heads over the correct media locations.

The controller Section;

The controller section is responsible for communication with the host computer and the disc drive. It receives commands from the host computer, makes decisions then controls the read/write section. Controllers may be divided into three areas, the controller processor (or controller), and the drive interface.

- The Host Interface allows the host computer to issue commands and provide parameters for the commands. Example : Read command, where to start and how much data to transfer.
- The Controller Microprocessor decodes commands from the host, makes decisions and issue commands to the drive to complete the host command. The language the host uses is different than language the drive uses so the controller acts as an interpreter.
- The Drive Interface lets the Controller Microprocessor communicate with the read-write section or thee positioning section.

The Read-Write Section.

The read-write section is responsible for writing data to the media and reading data from the media. This section responds to signals from the controller usually called write gate and read gate. These signals set the read-write circuits to either write data to the media or read data from it.

Data from the host computer must be encoded before writing it to the media, then decoded during the read operation. The read-write section is responsible for data encoding and decoding.

During write operations the host computer provides the data to the controller to be written to the media. The controller sets the drive up to the write circuits. The write circuits encode the data and send the data to the read-write head, which has been placed in the write mode. The heads write a magnetic pattern on the media. These patterns are written in areas called tracks. Since the media is circular the tracks are a circle of magnetic patterns on the media.

During read operations the controller places the read-write circuits in the read mode. The heads read magnetic pattern, convert it to a digital signal,

and decode the pattern. The send the read data to the controller where it is transferred back to the host computer.

The Position Section

There may be over 3500 data tracks on a single surface, each of them less than 300 million of an inch wide (0.003 inches). The average human hair is 3 thousandths of an inch in diameters. Therefore, it can be gotten 10 data tracks in the width of a hair.

The positioning section is responsible for moving the read-write heads over the correct track and keeping them on track. This section is usually called the servo section in the disc drive industry.

The controller knows where the read-write heads are positioned and decides if they need moved. If they do, it sends a command to the servo microprocessor to move the heads.

The actuator works like a small motor. It converts changes in input current to motion. The read-write heads are attached to the actuator. When the actuator moves the read-write heads move with it.

There are several critical mechanical components in the disc drive. These components are all part of the Head disc Assembly (HDA). HDA is the part of the drive that contains the read-write heads, the actuator the heads attach to, the media, and a motor to turn the media. In additional, the Has contain a lock to latch the heads in place during power down, an air filter, and sometimes a desiccant container. The desiccant container keeps the humidity of the air inside the drive at a certain level. These items are contained in a base deck assembly that will be sealed with a top cover.

The Spindle-motor is a specialized high-speed motor used to rotate the media. During drive operation, the media is rotated at speeds of 7200 to 10000 revolutions per minute. Disc media is typically placed on the spindle motor prior to the motor being placed in the base deck.

Rotating the media allows the read/write heads access to data locations all the way around the disc. It is these heads that read information from the disc or write information on the disc. Each head is capable of both

functions as it flies over the media. There is one head for each media surface moving in unison.

To move the heads in towards the center of the media and back, a rotary arm actuator is used. This actuator is made up of the read/write heads, flexible circuit assembly (flex), and voice coil, HSA to hold the heads and voice coil and permanent magnets. The actuator is positioned by the drive electronic circuits mounted to the HDAs. Electronic circuits used to position the actuator are called the servo circuits. The flex is a printed wired assembly (PWA) that contains the IC's that write the data to the media or read data from the media. It also may contain the servo amplifier that amplifies (boosts) the signals from the servo media. The flex differs from other PWAs because it bends as the actuator moves. Standard PWAs are constructed from a rigid material.

The read/write heads (heads) are the part of the disc that allow data to be written to or read from the media. Heads convert electronics signals to small magnets on the media during the write process. During the read process the heads detect changes in the magnetic pattern and convert them to an electronic signal. Most modern drives use either thin film or magneto-resistive read-write heads.

What does that have to do with disc drives? When power is applied to the disc drive and the motor starts turning the heads are touching the media in an area called the landing zone. When the motor reaches a certain speed there is enough airflow under the head to cause it to lift from the media and begin to fly. The heads fly between 1 to 5 millions of an inch above the surface of the media (depend on the products). Once the heads are airborne the actuator can move them across the surface of the media. To write data to the media it passes a current through the heads and begins switching its direction. The media is made of a material that is easy to magnetize, these materials are called ferromagnetic, which allows the head to "write" a magnet on the media. As the current in the head is switched the magnets are formed with a north and south pole. These magnetic changes store the data from computer.
The head must also be able to read a magnetic signal and convert it to an electrical signal. Another principal of physics tells us that when it passes a conductor through a magnetic field it generates an electrical current in

conductor. This principal has been used for years to create electricity with generators. The direction that the conductor cuts the magnetic field determines the direction of the current in the conductor, the speed that the conductor passes through the field determines the strength of the current. In disc drive this property is used to read the magnetic pattern from the media, and convert it back to digital data for the computer.

Head Stack Assembly (HSAs) product description;

The study is focused on the head stack assembly line only. As described; The HSA hold the read-write heads, flexible circuit, and the voice coil. Originally there were six read-write heads, it's depend on the requirement of product capacity. U2 product is six read-write heads in the HSAs. The Head Stack Assembly includes the read/write head assembly, actuator, flex circuit, and the voice coil. Following are the HSA picture and process assembly flow.

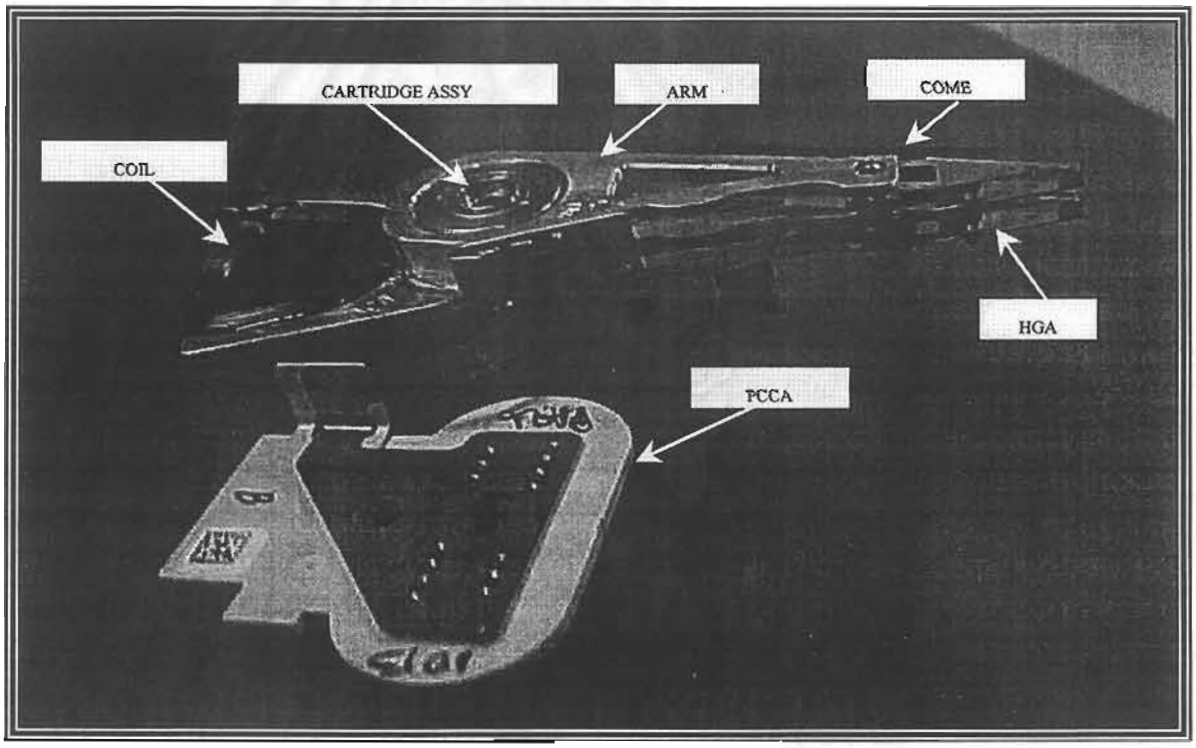


Figure 3.1: Head Stack Assembly (U2 product)

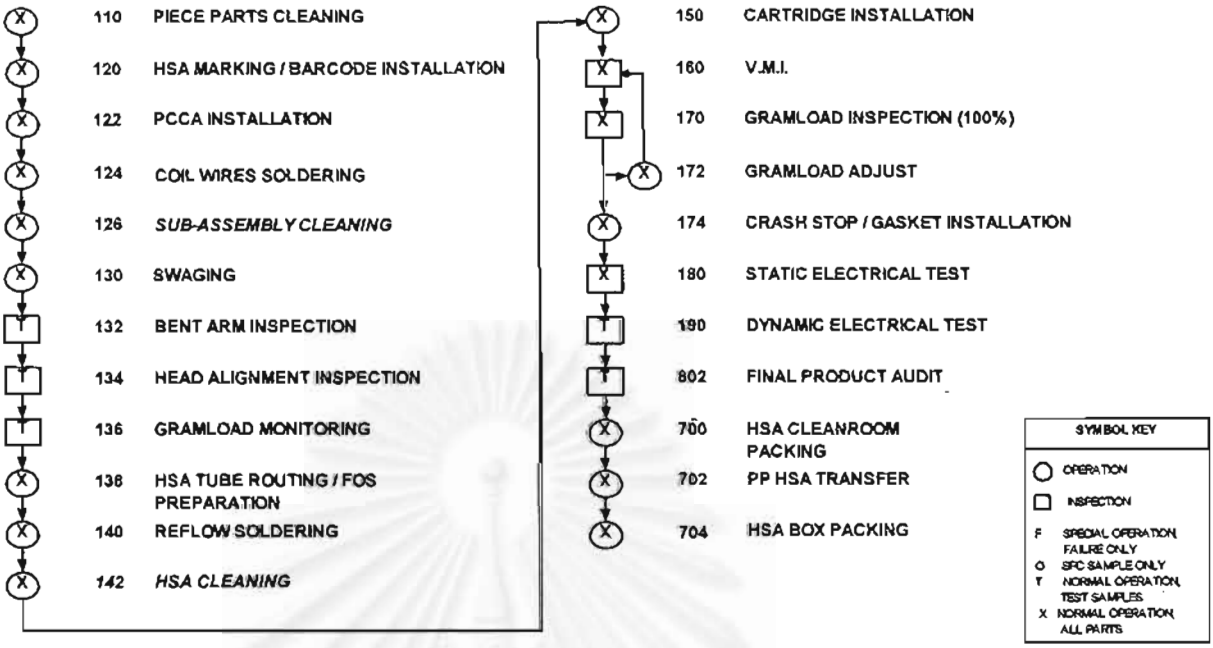


Figure 3.2: U2 Manufacturing Process Flow

3.2. Data analysis

According to the manufacturing process flow, the measurement data was collected from the Final Product Audit operation (FPA). Pareto of the defective is to identify the major top failures. Cause and effect diagram was performed on the top three failures and the FMEA was approached through the assembly process in order to specify and categorize the control parameters.

3.2.1 Data collection

The Final Product Audit (FPA) data was collected per the following.

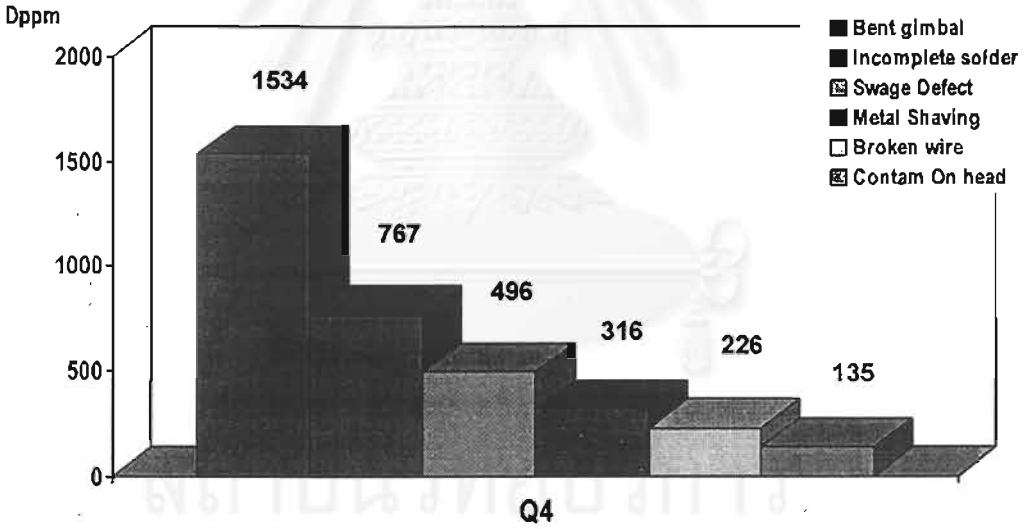
- Inspector operator carries out the outgoing / FPA inspection as defined in the inspection instruction procedure.
- Inspector records the result and data of inspection on the provided quality inspection record so-called DNP system.

- At the end of the shift, all data recording are to be segregated and grouped by type of report. A summary report will be published out by the quality assurance group as a daily, weekly, and monthly basis.
- Data record are kept as a record for verification and reference as;

  - Raw data (Check sheet) : Keep for 2 weeks.
  - Weekly report : Keep for 3 months.
  - Monthly report : Keep for 6 months.

3.2.2 Pareto Defective Analysis:

The pareto chart displays the principle of the significant few and trivial many. It is typically a few defects, items, etc. that are causing most of the problems. The Pareto Chart is a way of prioritizing efforts to eliminate problems.
The pareto diagram below is prioritizing the defective part per million Which measure during period of Q4 (April – June'98). It helps to focus on the most critical defects or causes and put effort to resolve the problems.



Defect	B/G	Incomplete Solder	Swage Defect	Metal Shaving	Broken wire	Contam on head
TTL Insp	22,164	22,164	22,164	22,164	22,164	22,164
TTL Rej	34	17	11	7	5	3
Dppm	1,534	767	496	316	226	135

Figure 3.3 FPA breakdown by defects in Q4 (April – June'98)

According to the pareto chart, the top Three major defects are Bent gimbal/flexure , Incomplete solder and Swage defects. The analysis will be performed by using Cause and effect diagram and FMEA on the top defects.

3.2.3 Cause and effect diagram analysis

The pareto diagram is normally used together with cause and effect analysis for developing corrective action. In this study, pareto analysis is used to identify critical problem or opportunity for quality improvement while the cause and effect analysis is used to identify causes relative to the effect, root cause of problems. This becomes to be the instrument for documenting and communicating quality improvement progress.

Cause and effect diagram analysis is a picture attempting to show the interrelationships between various inputs of the process and the poor quality and productivity outputs.

This tool will help to discover possible root causes of defects and then help to understand the failure mechanisms therefore it could be resolved and prevented right to the causes. Figure below are the cause and effect diagram that listed the possible cause from process, material, tool and workmanship.

Bent gimbal/flexure cause and effect diagram analysis

Bent gimbal/flexure is the major mechanical defect as shown in pareto chart. Bent gimbal/flexure very difficult to control due to handling through the process and also other parameter can be the cause of this defect. At this present, existing visual inspection at VMI operation and also gramload tester can detect this defect so both FPA and in process yield show high fall out rate of this defect. Goal is to improve the high defective rate to be zero defects.

Bent gimbal/flexure is mainly affecting drive performance and reliability because it will cause scratch disc due to there is an incorrect clearance

between head and disc so there is a specification called for to control this dimension.

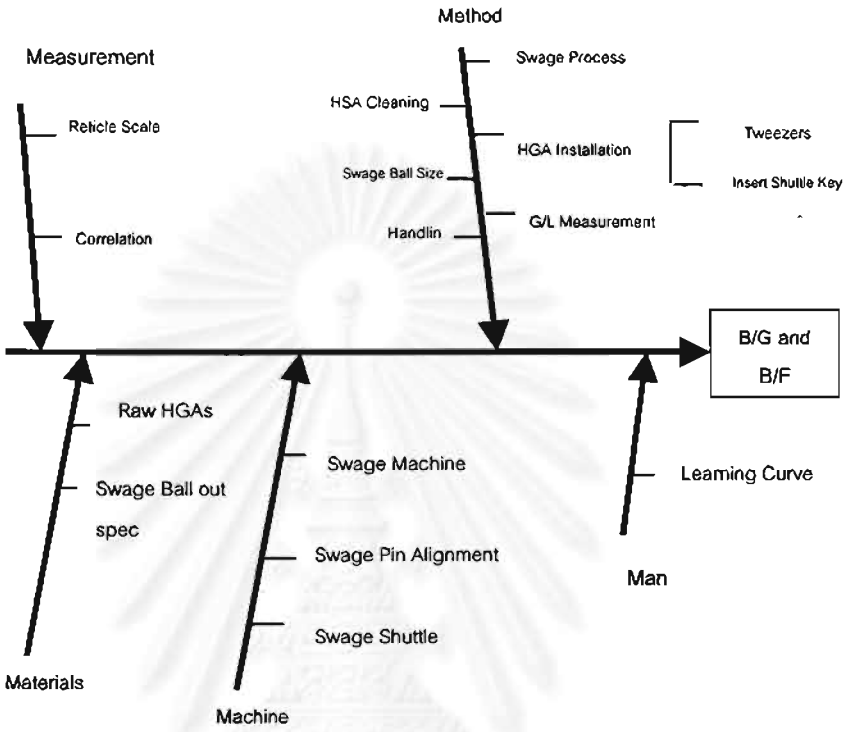


Figure 3.4 Bent gimbal cause and effect diagram

Swage defect cause and effect diagram analysis

Swage defect is caused from many parameters. This problem is occurred at swaging process which root cause can contribute from swage machine, swage shuttle (spacer key thickness), locking clamp, operator variation etc. The defect will affect at drive level. For example, swage push out is the damage, burr or shaving of stainless (flexure material) around swage boss area and this will scratch to disc.

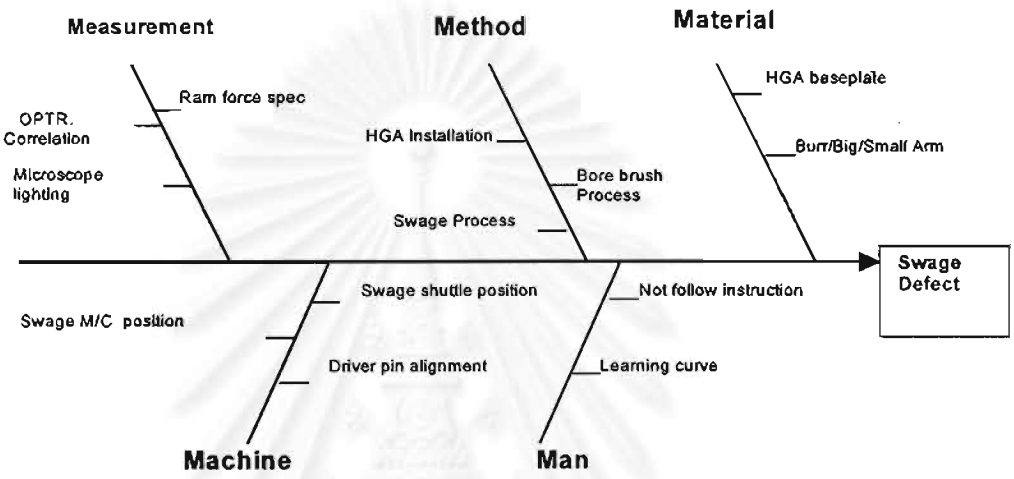


Figure 3.5 Swage defect cause and effect diagram

Incomplete solder cause and effect diagram analysis

The soldering defects are incomplete solder, solder splash (excessive solder height) and insufficient solder during head wire soldering process. There are many causes those related to incomplete solder problems. Cause and effect diagram below shows that there are many parameters can cause these defects such as temperature profile, machine time setting, solder tip force on the reflow solder machine, Pcc solder height, and also skill of workmanship are also considered.

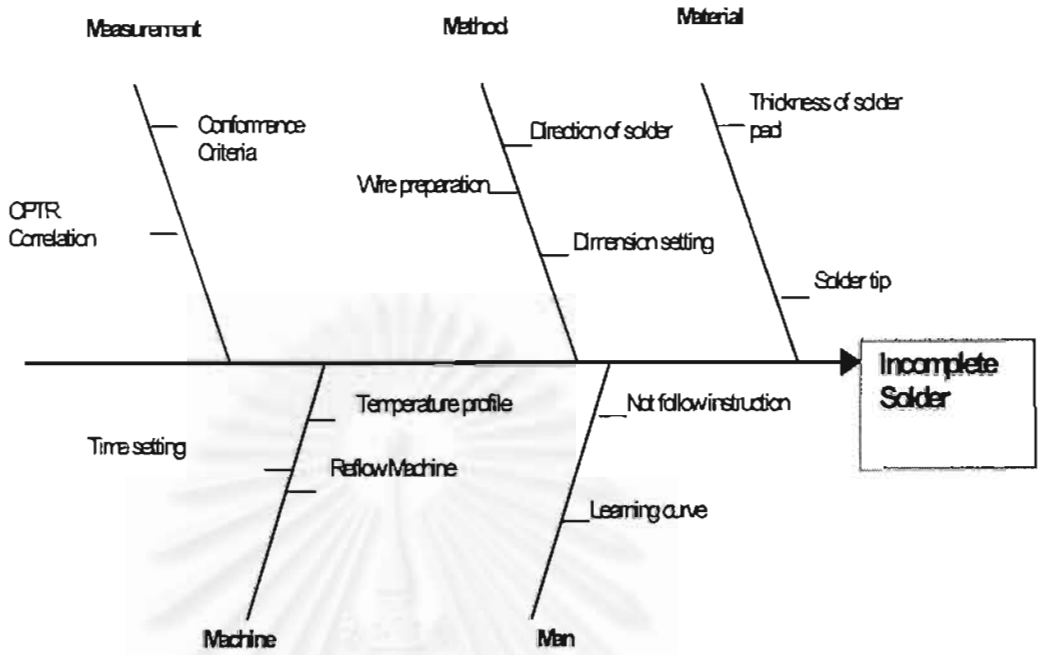


Figure 3.6 Incomplete Solder Cause and Effect Diagram

3.2.3 FMEA Analysis

At start, the FMEA team, which include development engineers, process engineers, quality engineer, tooling engineers, maintenance engineers and trainer, will be set up. Training will be provided to all people concerned.

FMEA provides a very powerful tool for design review and product assurance assessment. It should be applied since the first steps of the system and sub-system design. It is appropriate to all levels of a system, design, and process. The FMEA must be updated and the project progresses or the design matures.

Information form the FMEA can allow engineers to identify priorities for process controls and inspections tests during the manufacturing,

qualification, and approval processes. It provides essential diagnostic information and should be an integral part of quality and reliability planning.

A valuable use of FMEA is to identify and analyze problems, which may not be detectable or fully characterized during engineering model testing. In these cases, design assurance or reliability tests, or production volumes are necessary for the failure mode to become apparent.

- Identify failures that, when they occur alone, have unacceptable or significant effects on the system operation or performance.
- Establish the need for;
  Redundancy
  Features which increase the chance of fail-safe outcomes of failures
  Further degrading and/or design simplification
- Determine the need for selecting alternative materials, components, and processes. This can be done in conjunction with designed experiments.
- Identify serious (showstopper) failure consequences that require review.
- Disclose safety or reliability problems, or noncompliance with regulations.
- To ensure that test prototypes can detect potential failure modes.
- Identify tests and analyses required during prototype (engineering model) build.
- Focus on key areas where process or inspection control is needed.
- Avoid costly modifications by early identification of design problems.
- Establish the need for data collection and analysis during development.
- To support the design of fault isolation sequences or alternative modes of operation and reconfiguration.
- To facilitate communication between general and specialized engineers equipment manufacturers and engineers users and designers.

FMEA Procedure : (Ref. FMEA procedure. 1997. Seagate technology).

The concise procedure with 12 steps of FMEA easier for reading, understanding and following in each step of FMEA implementation are shown below.
The procedure for conducting a FMEA follows:

Step 1. Select a review team and tem leader.

A FMEA should include a team of four to six participants with representatives from cross-functional areas such as manufacturing, engineering, and maintenance. If a manufacturing process is involved, include at least one of the manufacturing operators, if possible. The team leader does not have to be the person most familiar with the process.

Step 2. Define the process boundaries.

A FMEA on an entire process would be extremely complex, and could possibly cause some potential failure modes to be overlooked. The process should be broken down into a series of subprocesses and a FMEA conducted on each, for ease of analysis. Some companies use separate review teams for each subprocess. Use process flow diagrams to help identify the boundaries of each subprocess to be studied.

Step 3. Brainstorm potential failure modes

The brainstorming should focus on the process under study and on the potential process failure modes that will affect the product. Remember, the product from this process will usually be the incoming material for another process. The approach could be brainstorming on all potential failure modes or it could be a series of directed brainstorming on each specific area: equipment and components, methods, material, people and the measurement system.

The brainstorming results should be organized and transferred onto the FMEA data collection form. Use a cause and effect diagram to aid in grouping related failure modes.

Step 4. List all potential effects of each failure

Next to each of the potential failure modes on the FMEA form, list the potential effects for each failure, describing what will results if this failure occurs. The failure could impact other components in the system, leading to a domino effect. It could impact the whole process. It could obviously affect the customer, whether it be an internal customer (the next system or manufacturing process) or an external (paying) customer. The description of the potential effects should be as specific as possible.

Step 5. List the potential causes of each failure

The potential causes will also be listed next to the potential failure modes on the FMEA form. These are the possible reasons why the failure could occur. This information is important later in the FMEA process to help direct the improvement efforts.

Step 6. List the current control.

For each the potential causes of failure, list the controls that are in place to prevent each cause from occurring to detect the cause of failure, or to detect the failure mode.

Step 7. Estimate the frequency or probability of occurrence.

The frequency or probability of occurrence fir each cause of failure is rated from 1 to 10.

This table is only applied for Seagate. Each factory or team may have their own rankings. The ranking system used must remain constant throughout the FMEA. In estimating the occurrence probability, consideration must be given to those controls designed to prevent the cause of failure from occurring.

Step 8. Estimate the severity.

For each of the effects of failure, rank the seriousness of the failure, if it had occurred from 1 to 10. Again, each factory should establish their own standardized ranking scale and criteria. Team working on internal processes to establish the system.

Step 9. Estimate the detection ranking.
The detection ranking is the probability of detecting a defect or quality problem before it is sent to the final finished goods and customers.

Step 10. Calculate the "risk"

This is not a statistical risk calculation. It is a relative ranking method used to prioritize the items with the greatest risk to focus improvement efforts. The calculation for "risk" is;

RISK = (OCCURRENCE) x (SEVERITY) x (DETECTION)

Where the highest possible risk is 1000 and the lowest is 1.

Step 11. Determine recommended actions.

The FMEA team should use the Pareto principle to identify those causes of failure with the highest risk. These will be the first items targeted for corrective actions, although the team should also consider improving those causes of failure with very high occurrence rankings. A cut off point may be set where all items with a risk greater than a preset "Danger" level (such as > 100) must be corrected before the process is put into operation.

To reduce the risk, the improvement effort can focus on :

- Reducing the probability or frequency of occurrence..
- Reducing the severity of failure occurring
- Improving the detection methods.

The improvement efforts may focus on only one of these areas or the efforts may strive for some improvement in all three to reduce the overall risk. The team should establish responsible individuals and set a due data for each of the items slated for corrective measures or improvement.

Step 12. Follow-up on actions

The team should review the actions taken and then revise the occurrence, severity, and detection rankings. The new risk number can be calculated from the new rankings to determine if the actions were effective in reducing the risk to an acceptable level. When all the ratings are below the danger level, the team may elect to disband. Of course, they may also elect to continue the improvement process by working down their Pareto of risks that are unsatisfactory. It is recommended that each FMEA team review their progress with management before they disband.

After the FMEA procedures have been developed, it becomes a living document and is never really complete. It is a truly dynamic tool for improvement because regardless of the beginning phase, it will use information to improve the system, design, product, process, or service. It is continually updated as often as necessary.

As stated earlier, in the major problems that U2 product line has experienced are bent gimbal/flexure, swage defect, and incomplete solder. Pareto chart and cause and effect diagram have been described and shown that there are many sources those could create the defects. The failure mode and effective analysis (FMEA) has been approached and implemented by the U2 team in order to define, identify, and eliminate the problems in the U2 assembly process.

FMEA team has qualified the severity, occurrence, and detection of each operation in the U2 head stack assembly process by referring to the Seagate FMEA guideline. The failures or defects collecting from each process operation were then analyzed using the brainstorming technique. The outcome from the meeting would be used to fill in the table of the FMEA form. Team will also decide whether what is the level of severity, occurrence, and detection based on team judgement and then will also include the details in the FMEA form.

The results after conducting the FMEA have been shown in the appendix II. Based on the evaluation results, there are many process parameters related to the problems. The team will decide to take action against respective

problems by determine the priority of those have been ranked by the RPN factor.

Following are the RPN ranked by operations, by parameters, and by defects.

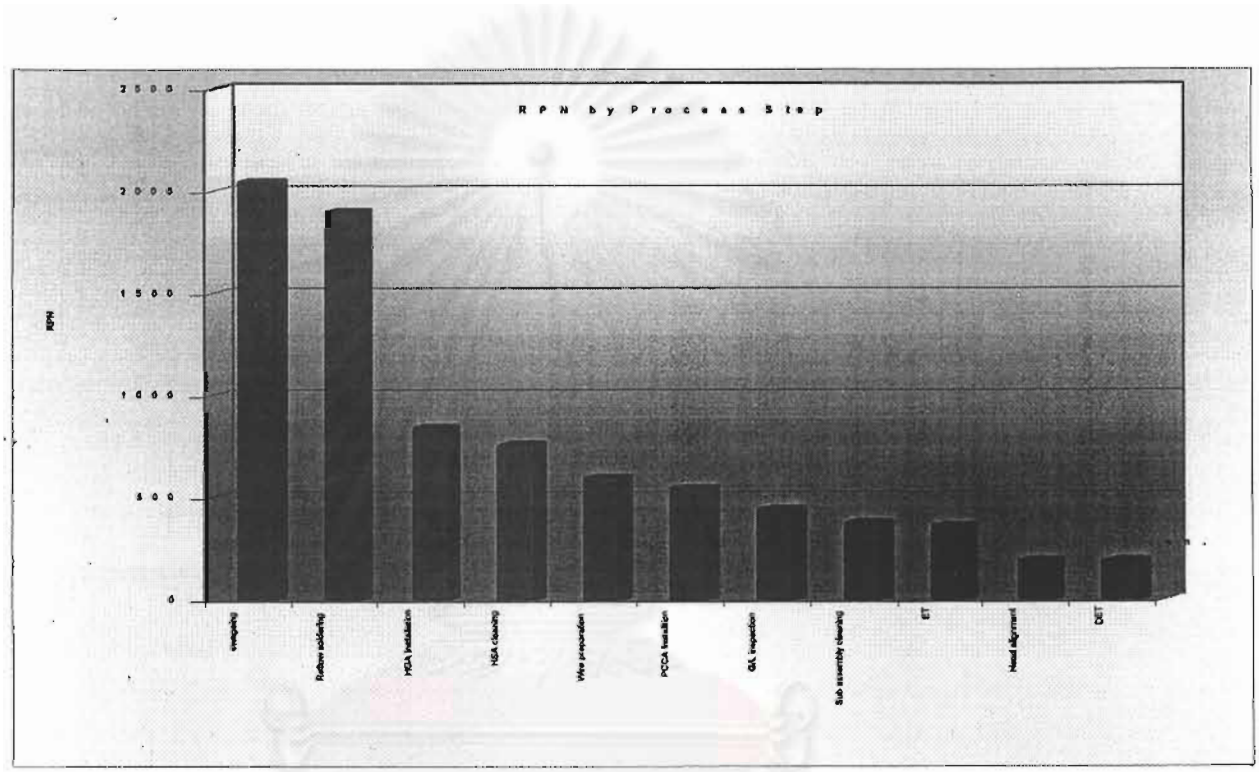


Figure 3.7 RPN ranked by process operations.

The FMEA team has discussed and ranked the RPN in order to highlight the high-risk areas in the head stack assembly process. From the figure above showed the cumulative RPN that combine each parameters in the operation from the highest to the lowest. Swage operation is the highest number RPN and DET is the lowest RPN.

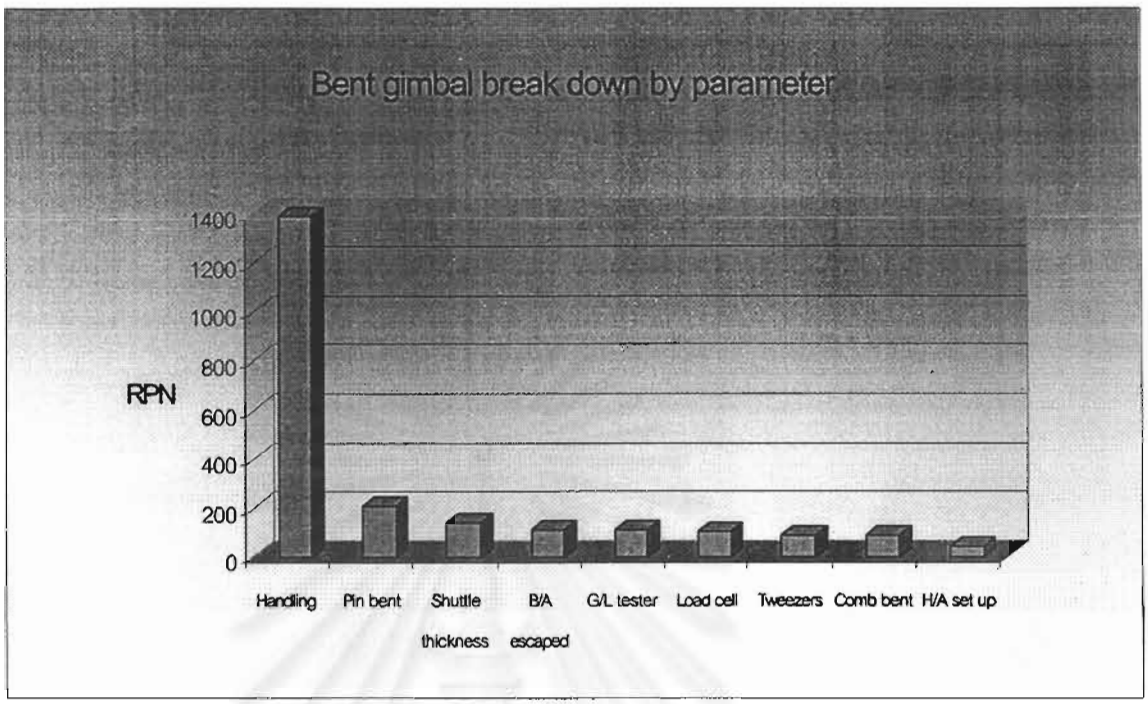


Figure 3.8 RPN ranked by effect parameters of bent gimbal defect.

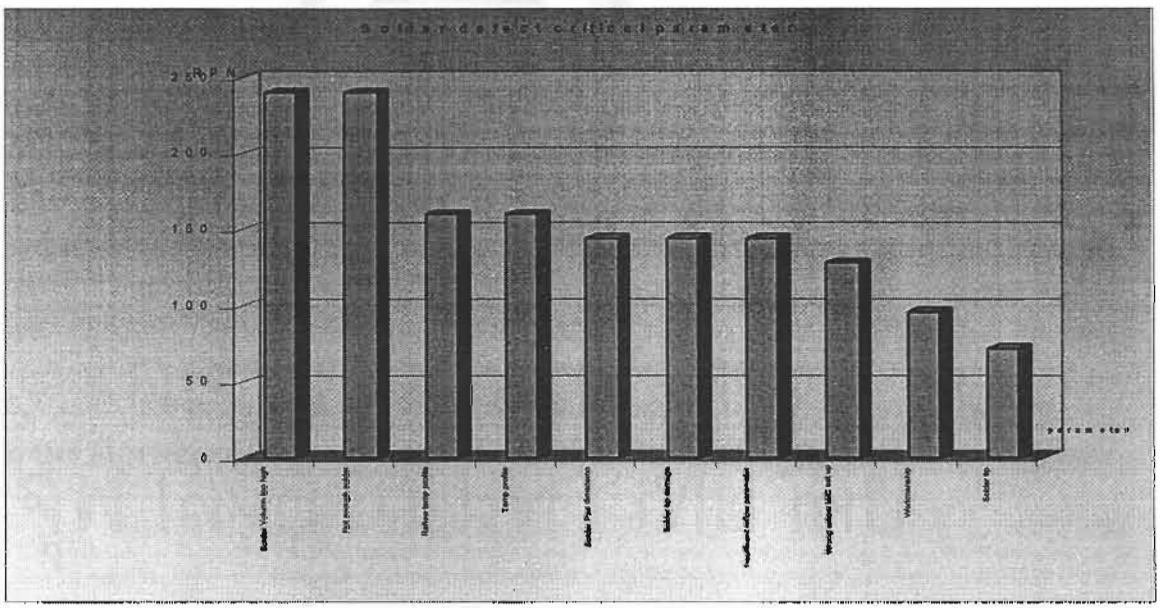


Figure 3.9 RPN ranked by effect parameters of incomplete solder defect.

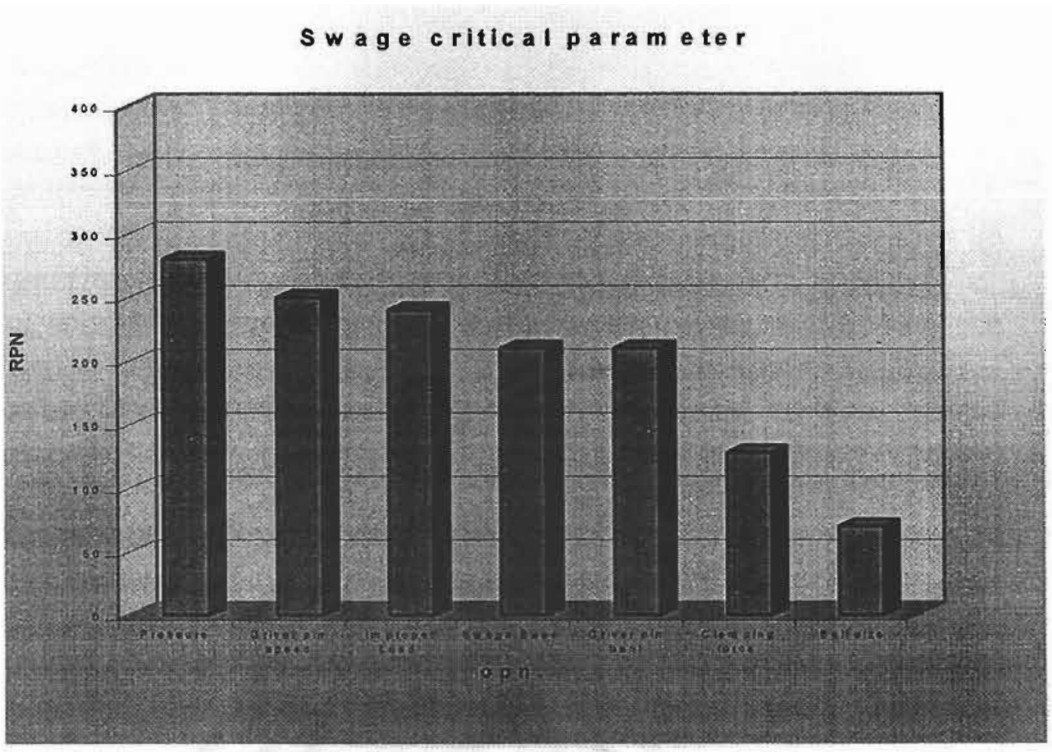


Figure 3.10 RPN ranked by effect parameters of swage defect

After the discussion among the members in FMEA team, the recommended actions and preventive action has been finalized and updated in the FMEA form. Team has concluded that the corrective actions and preventive action are required for all items and will select to act on the operation that showed highest RPN as first. The process control plan (PCP) will be established as for defining the continuous corrective action and corrective action. Finally at the end of the study, the RPN results showed significantly improved.

Chapter iv

New quality improvement and implementation

This chapter covering the quality improvement program and implementation phase which consists of four parts. The first is developing the process control plan "PCP". The second part is to set up the triggering mechanisms and corrective action flow. The third part is training to all members in the team including an operators and lastly the forth part is to set up the cell goal and rule to let everyone in the team understand the concept and cell target.

4.1 New cell HSAs line lay out approach

The new cell line lay out according to quality Improvement program, has been changed to be a single line. As described earlier that the product is characterized by the more complex assembly, the need for higher quality and reliability performance therefore the effective process control is needed. The current line is difficult to control as well as susceptible flow error while the new proposed flow will be more easily controlled. (See new line lay-out in figure 4.1)

After analysis of data and breakdown activities in areas of each process are completed, the final process control plan to be classified and categorized by the cause and effect diagram and failure mode and effective analysis (FMEA). The specification of control parameters in each operation is referred to the product print.

SINGLE LINE

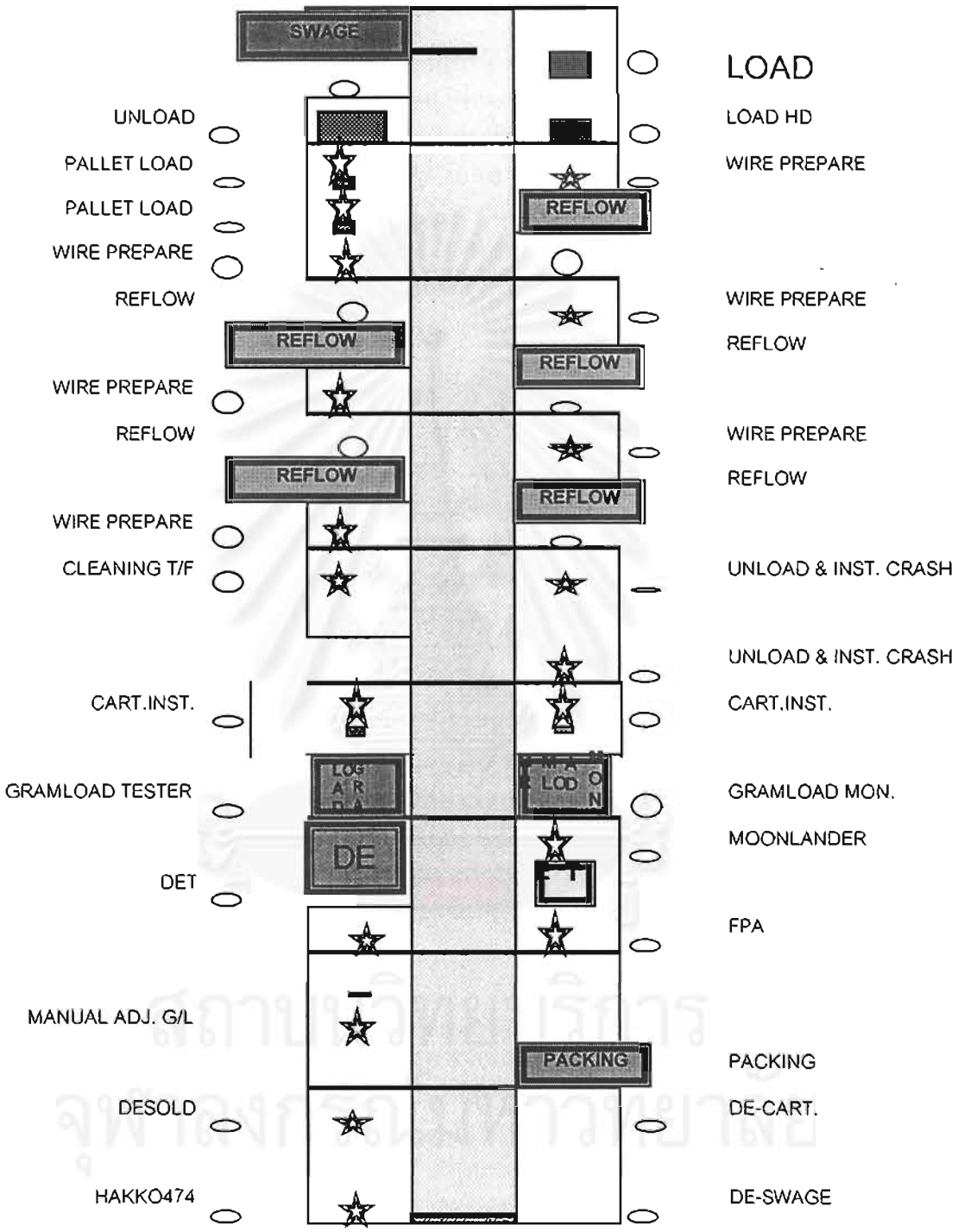


Figure 4.1 U2 Cell Layout

4.2 Process Control Plan (PCP)

The purpose of the process control plan is to aid in the manufacturing of quality products according to customer requirements. It does this by providing a structured approach for the design, selection and implementation of value-added control methods for the total system. Controls plans provide a written summary description of the systems used in minimizing process and product variation. The intend of the control plan form displayed in this section is to provide an example of how this information can be documented. The control plan does not replace the information contained in detailed operator instructions. The control plan is an integral part of an overall quality process and is to be utilized as a living document.

An important phase of the process for quality planning is the development of a control plan. A control plan is written description of the system for controlling parts and processes. A single control plan may apply to group or family of products that are produced by the same process at the same source. Sketches, as necessary, May be attached to the control plan for illustration purposes. In support of a control plan, process-monitoring instructions should be defined and used continually.

In effect, the control plan describes the actions that are required at each phase of process including receiving, in-process, outgoing and any requirements to assure that all process outputs will be in a state of control. During regular production runs, the control plan provides the process monitoring and control methods that will used to control characteristics. Since processes are expected to be continually updated and improved, the control plan reflects a strategy that is responsive to these changing process conditions.

The process control plan is maintained and used throughout the product life cycle. Early in the product life cycle its primary purpose is to document and communicate the initial plan for process control. Subsequently, the process control plan remains a living document, reflecting the current methods of control, and measurement systems used. The control plan is updated as measurement systems and control methods are evaluated and improved.

Designing process control plan

Its need to review since earlier at the start up, key items may need to be considered are;

- Process plans. Control plans should exist and be available at all times for all affected operations.
- Process instructions. Verify that these documents contain all the special characteristics specified in the control plan and that all analysis guideline such as, FMEA, Fish bone study, statistical analysis and etc. Compare the process instructions and process flow chart to the control plan.
- Gage and test equipment. Where special gages, fixtures, or test equipment are required per the control plan, verify gage repeatability and reproducibility (GR&R) and proper usage.

As discussed earlier in the Chapter iii, the analysis study showed, there are many factors can create the defects such as assembly tools, operators, raw material and method that provided in the operations. Following are keys operations and control factors based on the FMEA analysis. The control factors of each operations are listed as follow:

4.2.1 Control parameter for PCC Installation/ Coil wire soldering.

Purpose

Design of PCP at this operation is to ensure that the fixture and the soldering tip temperature are working correctly as specify in the procedure.

Parameter	Specification	Control/ Frequency
Solder tip temperature	300-400 degree-C-	Meter check/ Daily
Clamping Fixture	Proper lock	VMI Check / shiftly.
Tweezer	2A,258SA	VMI Check / Shiftly.

4.2.2 Control parameter for Sub Assembly Cleaning.

Purpose

Design of PCP at this operation is to ensure cleaning machine is working correctly within the control conditions.

Parameter	Specification	Control/ Frequency
Surfactant Valtron	1%	Shiftly
Cl	<0.1 ppm	Shiftly
NVR	<7 ppm	3 times / week
PH	6 – 8	3 times / week
Silicone	Zero	Monthly

4.2.3 Control parameter for Swaging operation of HSAs assembly;

Purpose

Design of PCP at this operation to ensure the swage machine is working correctly and within controlled conditions.

Parameter	Specification	Control/ Frequency
Motor speed	4 +/- Volts	Voltage / Shiftly.
Swage pin	0.031 " Dia	Diameter / Shiftly
Ball size	0.082"/ 0.083"	Size / 5 units/Shift
Pressure clamp force	80 +/- 0.5 Psi	Pressure / Shiftly.
Spacer key	0.087 " thick	Thickness / Shiftly.

4.2.4 Control parameter for Head alignment inspection.

Purpose

Design of PCP at this operation is to ensure the heads are positions in the correct specification, tooling inspection is conform correctly.

Parameter	Specification	Control/ Frequency
Machine GR&R	< 20%	R&R / Monthly.
Head position	+/- 0.008"	SPC chart/ 5 units/4 hrs
Yield trigger	98.5%	Signal light control

4.2.5 Control parameter for Reflow solder operation of HSAs assembly

Purpose

Design of PCP at this operation to control the Solder ability of the heads wire and PCC pads; To control the reflow solder machine are perform correct for the position, temperature and setting tip force.

Parameter	Specification	Control/ Frequency
Tip Temperature	200-250 °C	Temp/ Shiftly
Solder Time	0.02 Second	Time/ Shiftly
Solder Tip Force	150-250 grams	Force/ Shiftly
Solder tip life time	16,000 pads (max)	Counter/Shiftly

4.2.6 Control parameter for HSAs cleaning.

Purpose

Design of PCP at this operation is to monitor and control the cleaning machine is working within the control specification as specify in the procedure.

Parameter	Specification	Control/ Frequency
Surfactant Valtron	0.5%	Shiftly
Cl	<0.1 ppm	Shiftly
NVR	<7 ppm	3 times / week
PH	6 – 8	3 times / week
Silicone	Zero	Monthly

4.2.7 Control parameter for Cartridge install operation of HSAs assembly

Purpose

Design of PCP at this operation is to monitor and control the HSAs cartridge height and the tooling fixture are perform in the right position.

Parameter	Specification	Control/ Frequency
Cartridge height Fixture	Alignment	Alignment/Shiftly.
Pressure	70 +/- 5 Psi	Pressure/Shiftly

4.2.8 Control parameter for Gramload inspection

Purpose

Design of PCP at this operation to monitor and control the HSAs gramload inspection machine is running within the control specification.

Parameter	Specification	Control/ Frequency
Machine GR&R	< 10%	GR&R/ Monthly.
Preload	2.75 – 4.25 gram	SPC chart/ 5 units/4 hrs
Yield trigger	98.5 %	Signal light control

4.2.9 Control parameter for Static Electrical Test

Purpose

Design of PCP at this operation to ensure the Static Electrical Tester is working within the control conditions.

Parameter	Specification	Control/ Frequency
Tester R&R	> 90%	R&R/ Monthly
Standard units(confirm)	Passed/ Failed	Shiftly
Fixture/ Nest	No bent/Damage	VMI/ Shiftly.

4.2.10 Control parameter for Dynamic Electrical Test

Purpose

Design of PCP at this operation to ensure the Dynamic Tester is running under control.

Parameter	Specification	Control/ Frequency
Tester R&R	> 90%	R&R/ Monthly
Standard units(confirm)	Passed/ Failed	Shiftly

Table 4.1 Comparison of process control parameter (Before and After)

Opn.	Process	Control Parameter	
		Before	After
112	PCCA installation/coil wire soldering	- Tip Temperature	- Tip temperature - Clamp lock fixture
122	Sub Assembly cleaning	- NVR - CL - Silicone	- NVR - CL - Silicone - Surfactant contamination
126	Swaging	- Pressure - Ball size - Pin diameter	- Pressure - Ball size - Pin diameter - Motor Speed - Spacer key thickness
128	Head Alignment Inspection	- Machine R&R	- Machine R&R - SPC X $\bar{}$ bar R chart - Triggering yield

Table 4.1 Comparison of process control parameter (Before and After) (Continue)

Opn.	Process	Control Parameter	
		Before	After
134	Reflow soldering	- Time set-up - Tip temperature	- Time set-up - Tip temperature - Tip life cycle (16,000 pads) Tip force
142	HSA Cleaning	- NVR - CL - Silicone	- NVR - CL - Silicone - Surfactant contamination
148	Cartridge Installation	- Alignment Setting - Pressure	- Alignment Setting - Pressure
152	Gramload Inspection	- Machine R&R	- Machine R&R - SPC x bar R chart - Trigger Yield
155	Static Electrical test	- Tester R&R - Standard units	- Tester R&R - Standard units - Fixture/ Nest - Trigger yield
160	Dynamic Electrical test	- Tester R&R - Standard units	- Tester R&R - Standard units - Trigger yield
802	Final product Audit	- 0.4% AQL	- 0.4% AQL - FPA Triggering

4.3. Training and Certification

In order to achieve the goal, training team is very important and required. The training needs will be identified by the training team, a completed curriculum must be established and would be reflecting the training needs for all members in the team. The curriculum consists of at least an outline of all courses required by each group and an outline of what should be taught in each course.
Many training efforts to focus on how the members can be successfully implemented what they learned. If this question can not be answered or is answered with a "no", the training program is a failure.

The trainers become a part of the ongoing new cell effort of continuous improvement. The trainers will also closely monitoring the performance of the team.

The function of the trainer is to train, identify training problems, prioritize, analyze, and set up corrective action together with the team. Every operators is required to understand the new cell concept and the rules as defined by the team.

4.3.1 Principle of cell ownership A cell consists of all incoming materials from receiving areas, the production floor, tooling, fixtures, inspection tools, ESD control, and all facilities within the cell. The cell team which includes supervisor, technician, operators and support team who own the cell and are responsible for everything that might be happening in the cell. The operators own their work stations, tooling, cleanliness chairs, floor, etc. Support team (ME/QA/QE/QC/ Training/IE/PE/ Fac/ Prod) owns the cell. Quality Dppm, output yield, rework, scrap rate and floor control is the focus point of the team, therefore everyone in the team will need to be well trained.

4.3.2 Process control cell rules

The following rules are very important for the team to practice.

- Operator self -inspection. No reject to be passed on to the next operation or shipped to customers.
- Supervisors are responsible for operator quality (Dppm/ Yield).
- Operators/ Supervisors/ Technicians/ etc are responsible to stop an out of control operation using the "Light alert signal".
- Team members must immediately respond and correct problems.

- Supervisors will review status of rejects Dppm with operators and team members on a daily basis and all will plan corrective actions together.
- The team, supervisor, and operators own their production line and are responsible for quality of output, yield, Dppm, scrap, and rework from the start of process through final assembly operation.

4.3.3 U2 Team rapid response process

The rapid response process is the flow that define the responsibility of team when the problem occur or the troubleshooting in the process. Following is the finalized team rapid response process flow that has been implemented at U2 production line.

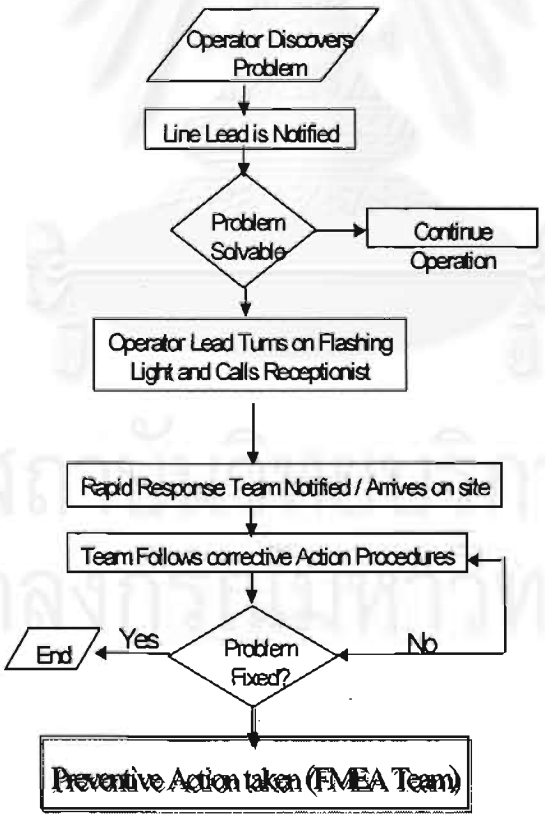


Figure 4.2 U2 team rapid response process

4.3.4 Cell goal for HSA manufacturing : Cell operator rules/ goal

The defined goal is zero defect from the operation. It is responsible for the quality of the product built in the operation and for everything that goes on at your work station. The green, red, yellow light alert signal has been installed so that it can help to notify all supervisor and the support team that the line/operation need help.

- Operator must perform a quick self-inspection check the work she did to assure that she was not passing product to the next operation which has a known defect.
- If operator know there is a problem with any of the following, she will stop the operation and turn on the **Yellow light**.

  a) Fixtures of tools b) Equipment c) Material

- Operators are responsible to check machine calibration stickers daily and to notify maintenance personnel if they find that something is past due for maintenance. An out of date calibration sticker means that operator must stop the operation and they need to turn on the **Red light.**
- If the station has an SPC chart, operators are responsible to know if the chart is in control condition. If the chart shows an out of control conditions, operator will stop the operation and turn on the **Red light**.
- Operator will keep the equipment, workspace, tooling, fixtures, floor and chair clean all the times.
- If a defect which came from another operation is seen, operator will immediately notify either supervisor using the **Yellow light** or the operation performing that operation.
- The **Green light** should remain on when operator think there are no problems.
- For product quality, time is critical. Do not continue to build when it is known there is problem which can be fixed. Use the operator **Red light** and get help.
- If there is a problem with getting help to fix problems, call the supervisor.

4.3.5 Cell supervisor rules/ goal:

Zero Defect from the Cell

- The cell includes everything from material loading through assembly till packing.
- Supervisor must assure that the product is not mixed with product from any other line through the entire process. Mixing is an

unacceptable defect. Incorrect identification or mislabeling is an unacceptable defect.

- Supervisor cell performance is based on the following measures;
  a) FPA Dppm
  b) Yield
  c) Customer returns and feed back
- The Green, Yellow, and Red lights installed in the line tell the status of the line. The light positioned throughout the line to allow any person (including operators) to ask for help or stop an operation. Supervisors are to response quickly to Yellow light since the Yellow light is use to asked for supervisor help. If they can not immediately solve the operator's problem, turn on the Red light to get assistance from the cell team. Red lights mean that the operation is out of control and is building product. The Red light is an operation stop light.
- Supervisors are responsible to assure that each operation receives help when it is required. The team members are assigned to help supervisor to correct problems quickly.
- As a member of the cell team, supervisor have the authority to correct things which are not correct and authority to present problems at the Daily team meeting for get help.

4.3.6 Cell team rules/ goal

Zero Customer Returns

- Everyone is now a member of the cell team and everyone will remain on the floor during normal production times.
- Everyone in the team is authorized to evaluate cell performance and to plan and implement changes which will improve quality or output. The team and operators within the cell and everything which happened within the cell.
- It is everyone's responsibility to get response to the red or yellow light. The red light will not be turned off until an acceptable quick fix is in place and agreed to by team members. The operator at the red light station is a member of the team and must approve team fixes.
- It is everyone's responsibility to perform casual analysis, do a quick fix of problems and put a permanent and preventive fix in place for all Red light problems. If the team can not put a preventive fix in place due to a lack of resources or knowledge. An issue will be discussed within the team for solution, if the problem still can not fixed, then highlighted to the management for help.
- The team's performance evaluation depends on the following;
  a) Dppm at Final product audit (FPA)
  b) Yield

c) SPC chart in-control and corrective action in place.

- Many other people from other functions support team's cell. The team has an authority to demand whenever it's required.

4.3.7 Improvement Team:

Team consists of members from all functions and is responsible for process maintenance and improvement. Includes members from;

a) Shusak R.	Team leader
b) Thanorm P	Production
c) Paradorn C	Process Engineer
d) Teerakorn C	Process Engineer
e) Apidee A	Quality Engineer
f) Chavalit k	Maintenace Engineer
g) Choochart k	Test Engineer
h) Decha C	Tooling Engineer
i) Rachanee C	QA Supervisor
j) Anakenan T	Trainer
k) Waraporn D	NPT Co-ordinator

- Process team overview: The process team can be called as a task oriented, a group solving the problems, which consisting of the those peoples from U2 product team (MFG/PE/ ME/QE /DE and etc).

  Members; The persons assigned to a particular team from the representative of that department. Usually, they are already the persons who was assigned to work on this products.

  Team leader; The person who was assigned to handle and set up this product since the start up.

- Team Training: Everyone in the team will require to be trained, the engineers (DE/ PE & QE) will provide the briefly product overview training to the staff of the team, this will include, product specification, process assembly flow, measurement and audit parameter and etc; Trainer will be trained to the front line operators for both theory and on the job training. Goals and rules will also be included.

- Steering Committee: The key point made here is the management supported. This project has been fully supported by the management team.

4.4. Triggering Mechanisms and Corrective Action Taken:

4.4.1 Triggering Mechanisms (LINE STOP):

The team has the job of implementing procedures that dictate when a manufacturing line should and will be stopped by a team member or lead. An increase in quality defects is the reason to stop the line. There are plenty of reasons to stop the line. The line should be stopped for major increasing of the proportion of defective product coming from the line. The manufacturing line also will be stopped for any condition that shows a trend toward or a point indicating an out-of control condition on a control chart.

Immediate action should be taken to remove the cause of the problem from the line. Preventive action will be taken to solve the cause and remove from the line. In many cases, production and quality people usually make up the members of the line stop team. Again, turn on the red light on that operation when need to stop the line.

4.4.2. Team focus for corrective action:

The corrective action team (CAT) is meeting held at a regularly scheduled time daily basis. The purpose of a CAT is to identify and eliminate problem and quality causing defects, thus affecting overall company profitability. Such problems are considered as major problems. Corrective and future prevention, therefore, require a team effort

The team is responsible for reviewing such problems and evaluating the problem. The team usually controlled and tracked for any problem and corrective actions were taken.

- Monitoring and reviewing defect.
- Setting long-term goals or activity objectives for defect or time reduce.
- Planning action to reach the long-term goals.
- Reviewing progress to goals and action plan.
- Assigning corrective action responsibilities.
- Reviewing and updating defect logs.

- Providing training in problem-solving methods.

The leader's of the team responsibilities include:

- Schedule and hold meetings.
- Ensure that all members are trained in new cell concept and techniques.
- Take a leadership role in discussion related to corrective action.
- Ensure that the CAT focuses on one clearly defined issue or problem at a time.
- Report the performance status.
- Keep the group on the road of continuous quality improvement.

Team members have the following responsibilities:

- Attend and actively participate in all meetings.
- Ensure that all action items are completed on time with quality performance and zero defects.
- Monitor all defects and take immediate corrective action on out of control conditions.

The general procedure for operation of the corrective action team is as follows.

1. Select a meeting time and place.
2. Inform all functional personnel of the time, place, and purpose of the team meeting.
3. During the first meeting introduce tem members to the purpose of team meeting and set up the goal of the team.
4. Clarify the major problem area for attack. Choose one part of the problem that can be solved in a reasonably short period of time (first round)
5. Determine a method for measuring the current status of the problem. Begin data collection and chart the average reject rate. This trend chart will later reflect the success of failure of each corrective action attempt.
6. Based on the current average, set a goal for improvement. This may be defect reduction, yield improvement.
7. Begin the implementation of your plan and review and adjust the implementation during every day meeting.
8. There are other concept for the team to consider
   A. Product Quality – Activities such as rework, inspection, test, returns, etc., are the activities that, if the jobs were done incorrectly the first time. The team should consider and make

and effort to track and reduce such additional costs as part of their regular activities.

B. Ownership- Everyone must do their jobs by correctly followed to instruction. Only good units will be allowed for passing to the next operation.

C. Who is the customer? The customer is the next person to receive the output of these activities. The customers vary depending on the particular activity performed during the day. All member's responsibility to understand and conform to their customer's requirements.

4.4.3 Immediate corrective action:

The floor team (MFG,IPQA,ME, Trainer, Fac) must be stationing in the production line which they can support production line all times . Whenever the light is on the team have to arrive at workstation quickly. The production supervisor has to put the name list on the cell so that the operators can call them immediately.
If the floor team can not make the decision on the failure ,they will need to inform supporting group (PE/QE/ DE or TE) to take the action. The supporting group will need to be on production floor quickly when they have notified.

4.5 Light alert signal:

The Light alert signal is a technique for quickly and visually showing the status of a line. This can be done in many ways. There are many types that can be used to flashing lights to show out-of control quality conditions, material shortages, or other problems. Light alert signal is also used to show material locations, material problem, process problem and everything goes wrong in the processes.

The light alert signal can be used in many cases. Operators, supervisor or technician can be used. For example; Based on SPC charts, red means an out-of-control condition and signals that the line should be stopped. Yellow means the trend is in control, but operating at an excessive reject level. Yellow is a signal directing to managers that it is the responsibility of management. A green light means that the chart is showing an in-control condition at low reject level. Red, yellow, and green light have been installed at the side of the cell which easy to be seen. They are showing status of each operation.

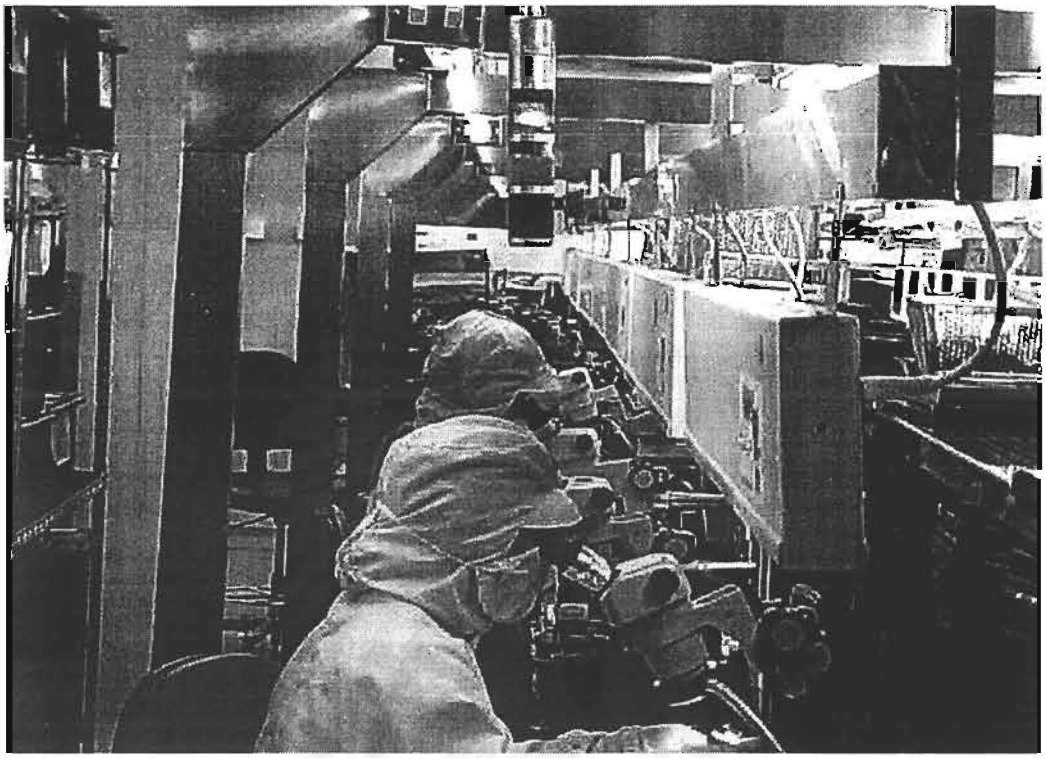


Figure 4.3 Photo of light alert system

4.6 SPC Control

Control means that the team collects data, plots the data and plans and implements corrective actions which establish and keep the trend under control according to target or SPC limits.

Process Control means collecting and analyzing data and taking immediate action to correct the process.

Statistical process control (SPC) meaning is infinite and complex. Many peoples giving many definitions, many books are written on the topic, but it depend to the requirement that they needed.

The U2 new cell manufacturing has also implemented the SPC control chart to monitoring the stability of the process and display the proportion

of defective product being manufactured. This can be part of the team monitoring activities. The out of control point will be discussed every day within the team to understand the changed and planed for preventive action.
Critical parameters (for dimensions or attributes that will absolutely cause the product to fail at the customer's or in the next process step) has been designed to be sampled. Mean and range control charts was established and maintained. Each critical parameter will have its own control chart to monitoring the process, with uniformly sized samples. Sometime, this critical parameter data also will be provided to the customers as a part of their needed and ongoing inquiry into how process control is maintained.

Everyone in the team must be known the basic requirement of the SPC, the process and quality engineer who is responsible in this process will be trained more not only control chart SPC technique, but with experimental research design and data analysis as well. The team will, in an effort to support, help design experiments, collect and analyze data, and help draw objective conclusions regarding the outcome of the experiment. The rest of the team members also should be part of an ongoing training effort to familiarize all organization personal, manufacturing or not, with basic SPC techniques and interpretation.

Everyone in the team will help to visually display the SPC chart. Corrective action then will be immediately in placed when it is out of control.

The team is responsible for establishing a system to measure, record, and display process capability (Cpk) information. Process capability summaries should be available for the critical measurement operation (see at PCP chart). The data will be automatically collected and calculated by the software that installed in the machines this allow for quick and easy capability reporting. The critical operations in the head stack assembly has been performed the SPC chart, following are the procedure;

Referred to the Process control plan (PCP), the SPC chart was performed at the operation head alignment checked and operation gramload checked.

Sampling checks the head stack assembly after swaging operation and gramload operation for 5 HSAs/tester.

- Record data in the record sheet
- Plot data in the $\bar{X}$-R chart

$$\bar{X} = \frac{X1+X2+X3+X4+X5}{5}$$

$$R = X\,max - X\,min$$

note : - If there is no production, do not plot zero value on the chart.
- Control limit of chart will be reviewed and provided by engineer.
- If the plot point is out of control limit of $\bar{X}$ or R chart, the action must be taken and recorded.

- SPC instruction for head alignment chart type $\bar{X}$-R

Machine	:	Head alignment tester
Part name	:	Head alignment assembly
Operation	:	Head alignment
Parameter	:	Head alignment
Specification	:	+ 0.008 Inch.
Sampling	size frequency	5 pcs/shift/machine

- SPC instruction for gramload

Chart type	:	$\bar{X}$-R
Machine	:	Gramload tester
Part name	:	Head stack assembly
Operation	:	Gramload
Specification	:	2.75 - 4.25 gram.
Sampling size frequency	:	5 pcs/shift/machine

note : Control limit formula for $\bar{X}$-R chart

UCLx	=	$\bar{\bar{X}}$+A2R	
CLx	=	$\bar{\bar{X}}$	
LCLx	=	$\bar{\bar{X}}$-A2R	
ULCR	=	D4$\bar{R}$	
CLR	=	$\bar{R}$	
LCLR	=	O	(if sample size < 5)

The SPC control chart is very powerful tool in order to make sure and monitoring the process to be stability. Following are the SPC definitions.

1. Control chart: A visual aids used for showing graphs to monitor / examine the stability of the process and homogeneity of the product to aware production of any changes to the product or process.
2. Control limits; The value of UCL and LCL calculated from the historical records based on statistical variation of the process can be established at the mean 1 +/- 3 standard deviations of the parameter.
3. Attribute control chart; A visual aids used for showing graphs to indicate each individual unit after being tested whether it is within the specified requirement, the quality measure " fraction defective" is commonly used.
4. Variable control chart : A visual used for showing graphs of " quality measurement" such as.
    a) The "average" of the observed valued of the individual units under consideration.
    b) Some measure of the dispersion of the observed around their average such as the "range" or "standard deviation"
5. Date collection chart: This first order of chart is used for setting up quality control limits from observed data.
6. Current control chart: This chart is applied on current process quality control to indicate abnormal in product or process.
7. Assignable cause: The cause of trouble that is evaluated through control limits. An assignable cause of variation may be attribute to lack of uniformity in materials or in workmanship or irregular

performance of manufacturing, equipment or testing equipment. The removal of such cause decreased the variability of quality or may result in changing the average of quality.

8. Out of control state: Where any points in graph of control chart fall outside the control limits or there is an indication of a trend, shift or nonrandom patterns. Time is the essence in the identification of an assignable cause presented.
9. Corrective action: The actions taken to assure that all problems are identified, verified and corrected.

SPC Chart at head stack process:

Operations	Parameters	Samples/Frequency	Chart
Gram load Test	Preload force	5 units/ 4 hrs	X-bar/R
Head alignment test	Head position	5 units/ 4 hrs	X-bar/R

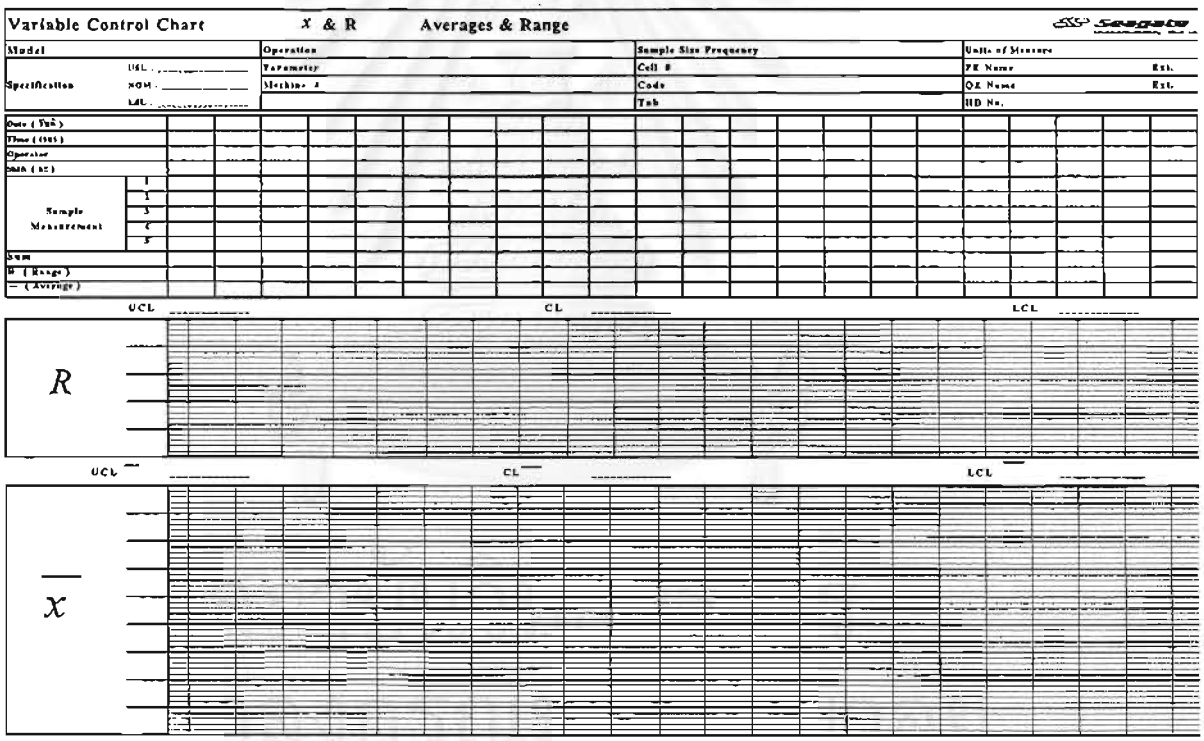


Figure : 4.4 $\overline{X}$-R Chart

4.7 Yield and FPA Triggering Control:

Line measurement and data collection: The new cell measurement point will still remain as same as the previous detail that presented on the PCP chart. The measurement point has also been defined as yield, FPA, SPC, and control parameter of each critical operation. The data collections are made through the DNP system which is available for operators to enter the data input number and defective code that found during the operation.

DNP is an automatic collecting data. All the input are from the production line. Operators have responsibility to key all the quantity of units that they do assemblies. All the information will be cumulative and reported to be production yield.

FPA Triggering Control; Before being sent out the final product to the finished goods areas, or another word is before packing and sending out units room the clean room., quality assurance department (QA) will take 0.4 % AQL sampling from each production lot. Testing is conducted in the clean room. These samples are subjected to visual and electrical testing in order to measure (in part per million) the average quality level (AQL) of all outgoing product.

Visual testing for mechanical defects is the visual inspection of the sample of the head stack assembly for any physical defects. If head stack assembly sample is found to have defect, for example, bent gimbal/flexure, Incomplete solder pads and/or etc, the whole lot must be returned to production for 100% visual inspection screen.

- At the beginning of each shift, the operators must be set up environments that DNP panels require and reset the DNP panels when finish at end of each shift.

- The production/operator must ensure that DNP panels are available.

- Technician or concern peoples must have the DNP Production Alert application (for monitoring) and ensure that it's available.

- The PC for the production alert application can be used as follow:
  - CPU pentium 100
  - Ram 8 Mbytes
  - HD 400 Mbytes above

- Technicians and concerned people are responsible to take actions/collection into production alert application.

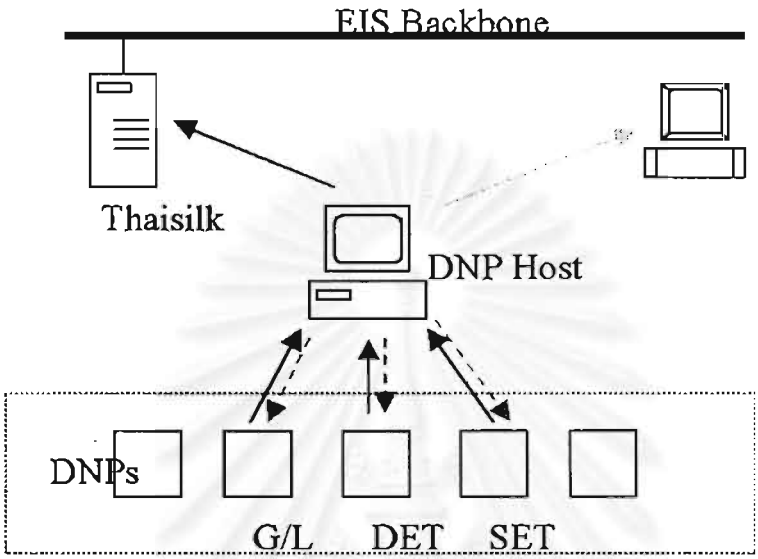


Figure 4.5 Transmission / Collection data of Production Alert system

Production alert system (PAS) is the tool to monitor the process yield, and FPA (Final product audit). It will alert and provide warning when the process is going wrong or changing. It is automatically alerting an operator and shut down DNP when process yield is out of control.

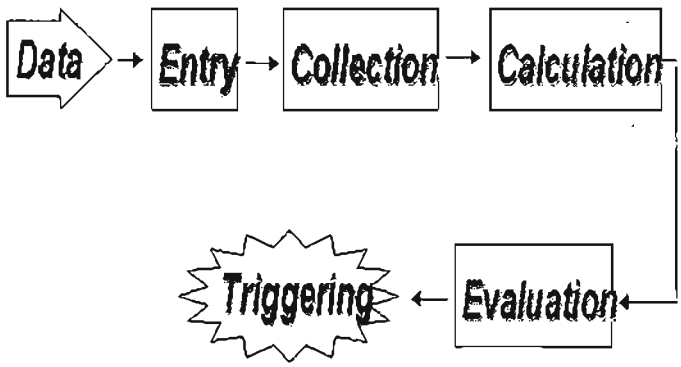


Figure 4.6 Data Flow Diagram of DNP Alert system

Production Alert System Instruction

- If data out of control limit, DNP panels will be shutdown.
- The operators will call technician who is responsible in the line to take the action.
- If machine has problem, technician will repair/ recalibrate machine.
- If HSAs/units have problem or the other cause related, the technician will pass issue to engineer that concern for verify and take action.
- After the engineer/technician take actions onto production alert application and then put the password into DNP panels will run again.

4.8 Tools & Equipment Preventive Maintenance:

The general concept of preventive maintenance is to continuously providing manufacturing with tooling equipment, and machinery which has periodic preventive maintenance. This function is under the control of the maintenance engineering.

The new cell are needs to be ensure that no fixture, tool, machine, or even soldering tip is left in a production line to be used until it was maintenance to make sure it will not causing the defect. One of the major failure are causing from the tools and fixtures. Preventive maintenance is like the preventive action to the defects. A schedule of maintenance will be designed and agreed on by the process engineer, quality engineer and maintenance engineer (which will include a production too). Some tools and equipment must be studies to determine the amount of wear out that is allowable before removal from the line, for instance; From the FMEA analysis result showed the solder tip of reflow solder machine will be worn out after 10,000 times soldered. So, it required to replace before that time. Certainly, production must have spares to keep production going during maintenance, or maintenance must be performed during non-working hours.

Every effort will be made to schedule, check, and maintain such tooling, equipment , or fixtures. In Disc drive manufacturing, it required very high accuracy and repeatable of tooling and equipment, preventive maintenance is very important. Many people have at some time to do

repair the tools when it already breakdown but in such case, the suffered may be more since the production may need to shut down.

The new cell quality improvement program was also included the maintenance parameter and schedule of each tools and machines. Maintenance check sheet also require at the operations. PCP was initiated and combined the control parameters to prevent such as failures.

4.9 Clean Room and ESD Control:

Temperature, humidity, particle count and electro static discharge (ESD) are monitored and controlled. Operators, supervisor or technician are monitoring the system on shift basis, the control chart are available at the production floor, if any parameter shows an out of control, the operation will require to stop till the corrective action been taken. ESD is critical for Head stack assembly process since the head is very sensitive to damaged by the static discharged that may be occurring during the operation, tooling or workmanship discipline.

Chapter v

Results and Conclusions

This chapter concludes the result of quality improvement program, which has been developed and implemented in the head stack assembly line (product U2). The results of the study is used the final product audit gate which measured in Dppm and presented before and after comparisons. The recommendations for further improvements of the system are also proposed.

5.1 Results

The quality improvement program in the new cell of U2 head stack assembly has been implemented on July '1998. The following results are summarized.

- It has been found that the overall final product audit (FPA) shows significantly improvement. The Dppm was reduced from 4,100 in Q4 (Apr – Jun'98) to 600 in Sept'98 and 124 in Nov'98.

WW#	Q4	July	August	September	October	November
TTL Insp	22,164	20,682	23,772	39,986	39,273	32,324
TTL Rej	91	21	25	25	9	4
Dppm	4,106	1,015	1,052	625	229	124

Figure 5.1 FPA comparison between before & after study

The breakdown of major failures are showed in the following Pareto chart.

- Bent gimbal defect was reduced from 1,534 Dppm in Q4' 1998 to be Zero Dppm in Nov'1998.

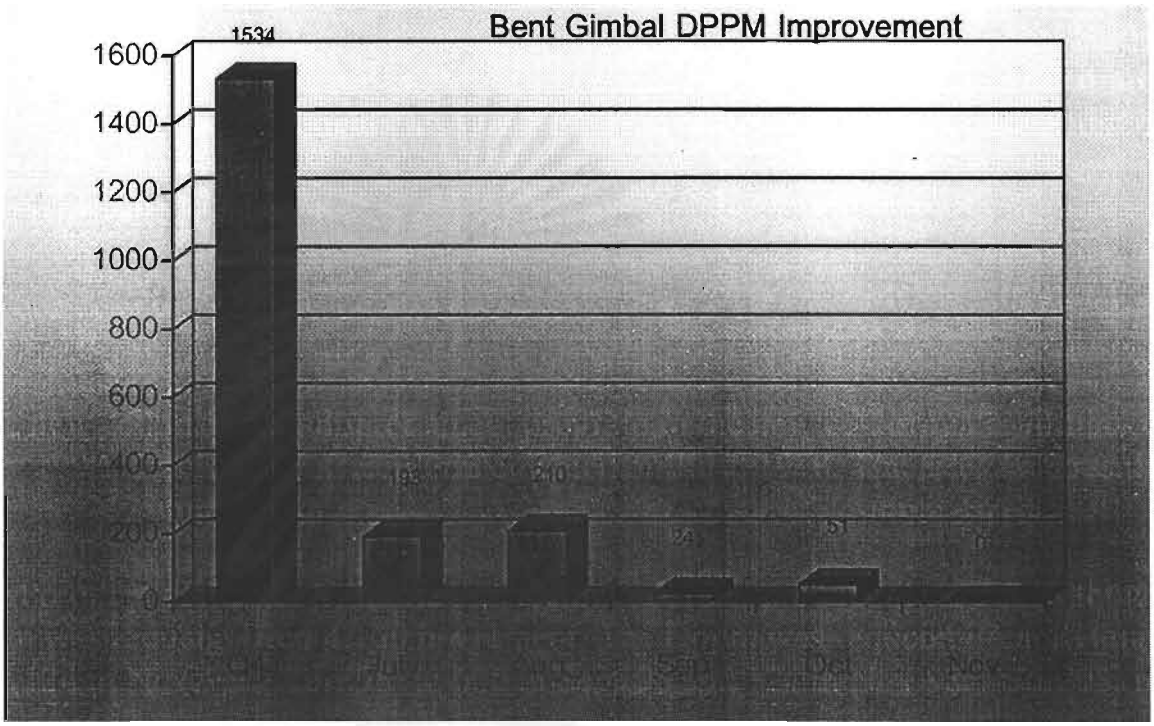


Figure 5.2 Bent gimbal FPA improvement trend

- The trend chart defects below showed the incomplete solder defect was reduced from 746 Dppm in Q4' 1998 to be Zero Dppm in Nov'1998. As described earlier in the part of analysis in Chapter iii, the major impact of incomplete solder are from the improper setting of solder tip temperature, Tip force, solder time and solder tip life cycle, including the solder pads height from the incoming of PCCA. The quality improvement team has been focused and acted to this issue in day to day. Process control plan was put in placed.

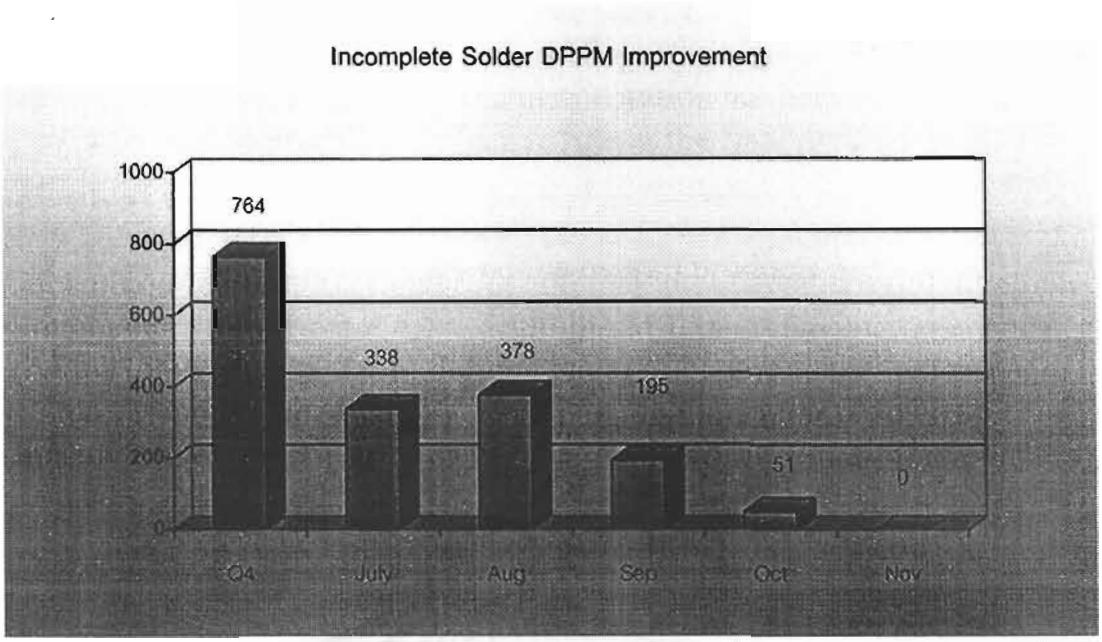


Figure 5.3 Incomplete solder improvement trend

- The FPA trend chart below showed the Swage defects was reduced from 496 Dppm in Q4' 1998 to be Zero Dppm in Nov'1998.

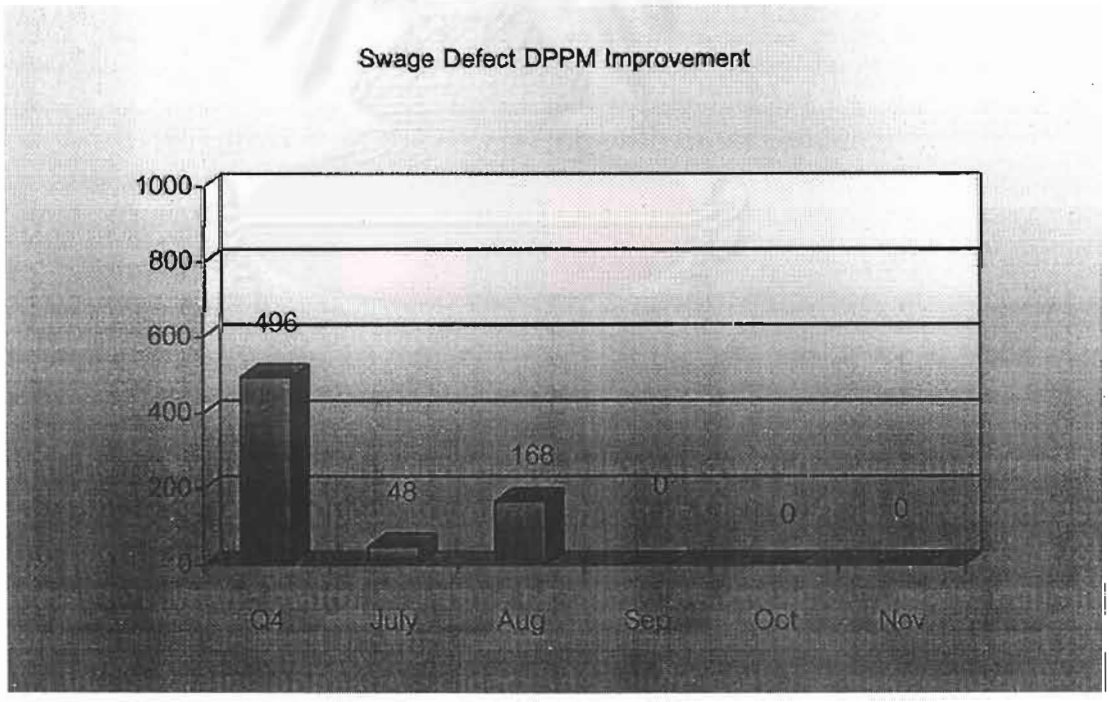


Figure 5.4 Swage defects FPA improvement trend

The quality improvement program on U2 product has been implemented in July '1998. The results of the implementation has been seen significantly improved. The defective rate at the final product audit (FPA) is achieved the target. Most of the major failure defects as Bent flexure, Incomplete solder and Swage defects have been resolved. The benchmarking chart below showed the overall products of FPA inspections. U2 product is the best.

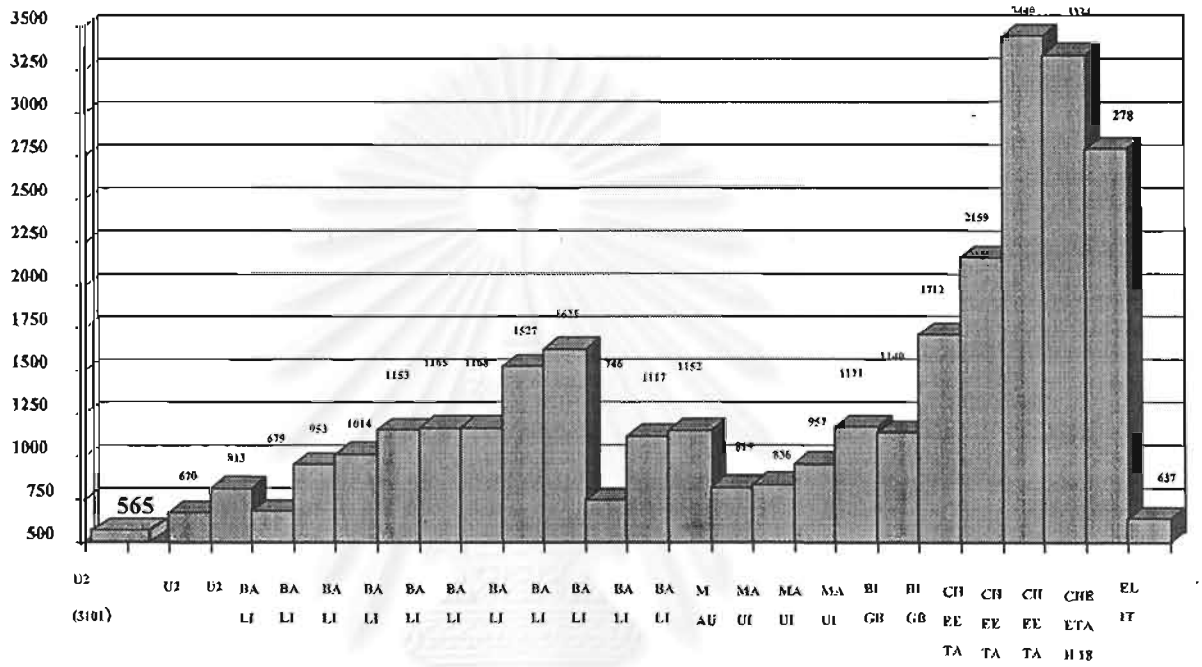


Figure 5.5 FPA comparison with other products

5.2 Conclusions :

The study of quality improvement system of the new cell in head stack assembly U2 product started from the analysis of old cell. The data collection of the old cell has been collected and analyzed as discussed in the chapter iii. Quality tools such as, Cause and effect diagram, Pareto chart and Failure mode and effective analysis (FMEA) were used in the problems analysis. The results from the analysis shown that there are many parameters in the assembly processes that need to be controlled. Control parameters was established together with specified the measurement tools, specification, and frequency of activities and the response persons. The process control plan (PCP) was generated and add into the official documented which is in the U2 process instruction. (Ref, the SOP # 2PW02007 standard format). See appendix III.

The new cell quality improvement system has been implemented in U2 product in July of 1998. The results of the implementation are collected through end of Nov '1998.

The requirements for improvement of quality are a common purpose and knowledge of concepts and methods so that change results in improvement of quality. This study aim to set up the quality improvement program for Head Stack Assembly in the disc drive manufacturing. The product was selected to study is U2. The outcome of the study, we can standardize the process control plan to improve the quality of the product and process. The next product coming may apply this study as a guideline for shorter time to market.

Historically quality control in the manufacturing has consisted of inspection of product. This program is mainly to focus for the process improvement so that a higher quality product at a lower cost can be achieved. Quality is increased by the use of new knowledge as a basis for changing the process or the product.

Through the research, the quality improvement program, tool and necessary quality technique were regarded major types of implementation of quality improvement program.

The focus of this study is to develop and standardize the quality control program in head stack assembly line to be more effective, especially in the environment of highly variable of new technology changed in the new product coming.

Many efforts has been coordinated and focused on a common purpose. Barrier between departments should be broken down so that team can work to perform a good quality. The key factor for success in improvement of quality is team working.

In the analysis phase, the major problems that U2 product line has experienced are bent gimbal/flexure, swage defect, and incomplete solder. Cause and effect diagram have been described and shown that there are many sources (5 M) such as machine, raw material, measurement, workmanship and method. The preventive action are listed and brainstorm in the team by following to the FMEA technique, the failure mode and effective analysis (FMEA) has been approached and implemented by the U2 team in order to define, identify, and eliminate the problems and the most importance thing is the preventive action.

FMEA team has qualified the severity, occurrence, and detection of each operation in the U2 head stack assembly process by referring to the Seagate FMEA guideline. The failures or defects collecting from each process operation were then analyzed using the brainstorming technique. The outcome from the meeting would be used to fill in the table of the FMEA form. Team will also decide whether what is the level of severity, occurrence, and detection based on team judgement and then will also include the details in the FMEA form.

Team Training and Follow up; Training is the first step before start up the program, implementation of the process control plan is a total team effort. Every person should become involved. Process engineer, quality engineer, test engineer, maintenance engineer, production supervisor, and technician will get together as a team, management will be supported of leadership and direction. Team training is very important to make sure the team members are clearly understood the objective and the procedure step by step. At the start up (U2 product); there is too much misinformation on what to do and support from the supporting team. Team training is required before start the program.

Team Decisions & Management support; Stop and fix the problem is one of the target of new cell concept. This is make a lot of pressure for the engineer, At the start up of the program, when they found a problem, they almost scare to make decision to stop the line. This is one of the key successes of the program. Management need to be supported and let them know that immediately stop the process and fix it is the right thing to do. Otherwise, we'll sending a vary clear signal to our operators that we are not really serious about quality. Even if it was marginal case, we should not waiting until the process was right by let the technician and operator continue their job. Stopping the process is force a solution to the problem, it require team to immediately fix that problem.

The successful implementation of the U2 new cell quality improvement program because of the team working, every one are solicited to identify not only problems, but potential problems, or even the opportunity for improvement. Realizes on experts person or individual person has not resolved the quality issues. Designed the quality control program is to guide the team to not only inspection and quality control, it has a number of disadvantages, including the time, defects from transportation, etc; it takes for parts to go through the inspection process and the fact that the inspectors often discover faults only after a whole batch either being scrapped or reworked. This is very expensive. The new cell quality improvement program is to improve quality by re-lay out the cell,

standardized the process quality audit & control, training team to act to issue as real time not re-act to the problems. Many befits can be summarized as follows;

- Make it right at the first time; achieving high quality it need to make it right at the first time of producing the unit. It guides the team to concentrated attention to the process, potential of problems, detecting the problem and solving the problems.

- Eliminate the separate inspection operation by having the operators monitor the process and take corrective action immediately when defective was found. Visual aid guideline was provided at the work operations to help an operator to clearly understand the criteria.

- A change of culture in front line people; This is seeking to introduce the new culture for front line peoples, it has a more cooperative environment at the production line. Every one focus at the same target and goal, Team is working close together to get the problem resolved.

- The key factors to achieve are, effective process control plan implemented, team working, management supporting, and real time corrective action taken.

- Standardized process control plan and quality improvement program was initiated. The next product transfer coming will be using this standardize program to set up.

5.3 Recommendations:

Overall performance of product U2 has a good level of quality, continuous improving of weaknesses can be performed in order to have better level of quality and maintain, particularly to get excellence. Following are some recommendations.

- Pay much attention in the training of basic and important statistical quality control courses for all concerns. In addition, tools and techniques such as SPC, FMEA and basic statistical.

- This study should be viewed as a starting point of the Head Stack Assembly. The important of further research is recommend to study of the integrated cell (IC line), which being developed to merge assembly line between HGAs and HSAs.

- From analyze, the U2 program strengths and weakness can be determined and list as following.

Table 5.1 Strength and weakness of product study

Strength	Weakness
Information and data analysis ▪ Analysis tools and techniques are available to be supported. Sufficient data are prompted	
Organization ▪ Clear organization structure which makes employees very well perceived. ▪ Good interdivisional harmony and team Work	▪ Sometime supporting group has not been paid enough attention.
Training ▪ Good success in designing of training program. ▪ Employees understood deeply in The program concept. ▪ Well understood in important tools ▪ Problem solving involvement of employee.	▪ Employee's understanding are still not very good in some tools such as, SPC control.
Quality assurance activities and rewards ▪ Provide the rewarding programs for the best achievement team.	▪ Appropriateness of rewards and recognition.
Daily management and improvement activities ▪ Performing and monitoring of control items. ▪ Improvement plan is continuously daily team discussed.	▪ Low statistical techniques utilization.

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Appendix I

Model : U2	Part Name : ST-31013 ST-32111 ST-33223 ST-34323	Part No. : 22200376-091 22200373-091 22200370-091 22200365-091	Customer Name: STCO STMP STSZ	Prepared : U2 Team	Confirmed : Shusak R.	Approved : Boonmee P.	Date : June 23 '98	Rev. A
MFG Opn. ○	MFG Inspection / Te ◎	QA. Audit / Test □						

Process flow Opn.	Process	Facilities / Equipment required	Check Points				Sampling				Trigger System		
			Calibration	Maintenance	Product Characteristics / Process to be audited	Specification	Sampling Plan (Qty / Freq)	Recording Method	Responsible Person	ool or checkir Method used	Limit	Light Color	Responsible Person
(113)	PCC Installation / Coil wire soldering	Fixture Solder tip 144 2A-SA, 258-SA, 3C-SA tweezers	No No No	Monthly Weekly Daily	- Clamp lock - Temperature - Bent / Damage	Properly lock 300 - 400 degree celcius Not allow	100% shiftly Daily 100% shiftly	No Check sheet No	Operator Technician Operator	Visual check Meter Visual check	Not lock Reject Reject	Yellow Yellow Yellow	Technician Technician Supervisor
(122)	Sub Assembly Clean	Crest machine	No	Weekly	- Surfactant of Valtron 2275 - Cl - NVR - PH - Silicone	1 % < 0.1 PPM <7 PPM 6 - 8 0	Shiftly Shiftly 3 times / week 3 times / week Monthly	No water Cleanlin Result	Technician ESD & contam cont group	Label M&P Lab.	Not Correct Out of spec	Signal Signal	Technician
(126)	Swaging	- Mortor speed - Spacer key - Pressure gauge - Needle Pin - Melonite ball	No No No No No	Monthly Shiftly No Shiftly No	- Voltage - Type & Thickness / Burr - Pressure - Pin diameter - Ball size	4 +/- 0.5 Volts Flat/Step at hd 0 & 3 / 0.087" 80 +/- 5 Psi 0.031" Prime - 0.082" 1st R/W - 0.082" 2nd R/W - 0.083" 3rd R/W - 0.083"	100% shiftly 100% shiftly 100% shiftly 100% shiftly 5 ball/size/machine /shift	Check sheet Check sheet Check sheet Check sheet Check sheet	Technician Technician Technician Technician Technician	Volt meter Caliper Visual check Caliper Micrometer	Out of spec Reject Out of spec Out of spec Reject	Yellow Red Red Yellow Yellow	Technician Technician Technician Technician Supervisor
(128)	Head Alignment Inspection	Head Alignment Machine Master gauge Standard unit (for confirmation)	Shiftly (confirm by standard unit) Interval 3 months Shiftly	Monthly Shiftly No	- R&R - No - No -SPC Chart	< 20 % Spec +/- 0.008"	10 unit / month 5 unit /machine /4 hrs.	R&R form DNP X bar - R Chart	Technician QC operator	GR&R Statiscal Tech	Out of spec 98 % yield Out of spec	Red Red Yellow	Technician Technician Technician
(134)	Reflow soldering	Reflow soldering machine Solder tip	Interval 2 months No	Shiftly Monthly	- Temperature & Time setup - Actual temperature - Solder tip force - Solder tip life time	300 - 500 degree Celcius / 0.20 Sec. 200-250 degree Celcius 150 - 250 grams 16000 Pads max.	Shiftly Monthly 100% shiftly 100% shiftly	Check Sheet Check Sheet Check Sheet Check Sheet	Operator Technician Operator Operator	Visual Check Thermometer Visual Check Visual Check	Out of spec Out of spec Out of spec Out of spec	Red Red Red Red	Technician Technician Technician Technician
(142)	HSA Cleaning	HSA Cleaning Machine	No	Monthly	- Surfactant of Valtron 2600 - Cl - NVR - PH - Silicone - Particle count (under lamina	0.5 % < 0.1 PPM < 7 PPM 6 - 8 0 < 100 Pcs. / Size 0.5 Micron	Shiftly Shiftly 3 times / week 3 times / week Monthly 1 point / day	No water Cleanlin Result Check Sheet	Technician ESD & contam cont group	Label M&P Lab.	Not Correct Out of spec	Signal Signal	Technician

Personal Responsible □ Technician ○ Operator ◎ Inspector

Model :	Part Name :	Part No. :	Customer Name:	Prepared :	Confirmed :	Approved :	Date :	Rev.
U2	ST-31013 ST-32111 ST-33223 ST-34323	22200376-091 22200373-091 22200370-091 22200365-091	STCO STMP STSZ	U2 Team	Shusak R.	Boonmee P.	June 23 '98	A
MFG Opn. ○	MFG Inspection / Test ◯	QA Audit / Test □						

Process flow Opn.	Process	Facilities / Equipment required	Check Points				Sampling				Trigger System		
			Calibration	Maintenance	Product Characteristics / Process to be audited	Specification	Sampling Plan (Qty / Freq)	Recording Method	Responsible Person	Tool or checking Method used	Limit	Light Color	Responsible Person
(148)	Cartridge installation	Cartridge install fixture	No	Monthly	- Alignment setting	Not mis-align	100% shiftly	Check Sheet	Technician	Visual Check	Out of spec	Yellow	Technician
		Pressure guage	No	No	- Pressure	70 +/- 5 Psi	100% shiftly	Check Sheet	Technician	Visual Check	Out of spec	Yellow	Technician
[152]	Gramload inspection	Gramload tester	No	Monthly	- R&R	< 10 %	10 unit / month	R&R form DNP	Technician Operator	Statiscal Technic	Out of spec 98.5 % yield	Red Red	Technician Supervisor
					- SPC Chart	Spec. 2.75 - 4.25 grams	5 unit /machine /4 hrs	X bar - R Chart	QC operator	Statiscal Technics	Out of spec	Yellow	Technician
[158]	Static Electrical test	Moonlander III	Monthly	Monthly	- Correlation & R square	> 90 %	24 HSAs	R&R form	Technician	Statiscal Technic	Out of spect	Red	Technician Supervisor
		Standard unit (for confirmation)	Shiftly	No	- Test parameter F6 - Fail coil resistance F7 - Fail Coil Polarity F9 - Fail Coil Short to Ground F15 - Fail test power supply F24 - Fail reader F25 - Fail writer F41 - MR polarity F50 - MR Resistance F29 - Other Failure	 17.5 +/- 1 Ohm. Not allowed Not allowed Not allowed Not allowed Not allowed Not allowed Not allowed 27 - 49 Ohm. Not allowed						
		Fixture / Nest	Shiftly	No	- VMI	No Bent / Damage	Shiftly	DNP No	Operator Opertor	Visual Check	99 % yield Reject	Red Yellow	Technician Technician
(160)	Dynamic Electrical test	Guzik tester	Monthly	Monthly	- Correlation & R square	> 90% & 80%	24 HSAs	R&R form	Technician	Statistical Technic	Out of spec.	Red	Technician
		Standard unit (for confirmation)	Shiftly	No	- Test parameters HF TAA LF TAA OVWR PWNBOTH LF_TAASM	 > 80 mV. > 100 mV. > 27 dB. < 20.2 nS. -17% to 17 %	DNP X bar - R Chart				98 % yield	Red	Technician
[802]	Final product audit (FPA)	Microscope	Interval 4 months	Visual defect / workmanship	- Accept / Reject	0.4 % AQL	FPA failure report	QC inspector	QC inspector	Visual check	1 unit reject	Red	Supervisor
				SET test	- Pass / Fail	0.4 % AQL	FPA failure report	QC inspector	QC inspector	Tester	1 unit reject	Red	Supervisor

Personal Responsible □ Technician — Operator — ○ ○ Inspector

Appendix II.

POTENTIAL

FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item: HSA | Process Responsibility: U2 Product

Core Team: U2 Team

FMEA Doc Number #: U2 1302

Page: 1 of 5

Prepared By: Shusak R.

FMEA Date (Or: Jun ' 1998

FMEA Date (Re: Dec ' 1998

Process Function and Requirements	Pocess Step	Key Process Inpot	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential cause(s) / Mechanism(s) of Failure	Occur	Current Process Controls	Detec	R. P. N.	Action Priority	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	R. P. N.
PCCA Installtion /	PCCA Installation	PCC / Fixture /	- Incomplete solder	- Failed ET	6	- Worn out manual tip	5	Tip temperature (Not	4	120	B	-Shifty PM to check tip	Decha	Done	6	2	2	24
Coill wire soldering	Coill wire soldering	Manual tip/						specific frequency)				temperatuer performance		ref. PM				
		fixture																
			- PCC Misalignment	- Incomplete solder	2	- Improper clamping	8	No	10	120	B	-Shifty check clamping / fixture	Decha	Done				
						- Worn out fixture	5	No	10	100	B	and add into PM procedure		ref. PM	2	2	2	8
			- Damage PCC	- Failed ET / VMI	7	- Handling	4	Process instruction	3	84	C	-Team training and	Thanorm		7	2	1	14
												follow up with self insp.						
			- Loose coil wire	- Rubbing to magnet	8	- Raw material	4	Incoming inspection	5	120	B	-Self inspection and visual aid	Thanorm		8	3	3	64
				pole								form provided.						
Sub assembly cleani	Cleaning	Sub assembly	Contamination	- Disc scratch	5	- M/C wrong set up	5	- Audit set-up parameter	5	125	B	- Standardizing process	Shusak	Done	5	2	4	40
		cleaning M/C										cleaning parameter		ref.PI				
		cleaning fixture				- Incoming of DI wafer	4	- Cleanliness test	5	100	B	- Add more parameter	Shusak	Done	5	2	3	30
								- NVR				- Surfactant contamination		ref. PI				
								- Cl										
								- Silicone										
			Bent Arm	- B/F	5	- Worn out	6	- VMI by rack	5	150	B	- Add PM to check cleaning	Decha	Done	5	2	2	20
												rack		ref. PM				
												- Standardizing cleaning rack	Shusak	Done	5	1	2	10
												design		ref. DWG				
HGA Installation	HGA Installation	HGA / Swage /	Bent flexure /	Failed G/L tear	7	- Head Alignment pin	6	- Naked eyed head	5	210	A	- Shiftily head alignment	Thanorm	Done	7	4	3	84
swageing		Shuttle / Arm	Bent Gimbal	down		bent		alignment pin checking				checking by go guage		ref. PI				
				Bent flexure		- Shuttle key thick ness	4	- Sampling check shuttle	5	140	B	- Revised PM Frequency	Decha	Done		2	3	42
								key thickness				to be daily		ref. PM				
						- Bent arm escaped	4	- Naked eye	4	112	B	- SQE incoming sampling check	Verawat			3	3	63

POTENTIAL

FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

FMEA D. Number # U2 1302

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Item HSA Process Responsibility U2 Product Prepared B Shusak R.

FMEA Date (Or Jun ' 1998

Core Team U2 Team FMEA Date (Re Dec ' 1998

Process Function and Requirements	Process Step	Key Process Input	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential cause(s) / Mechanism(s) of Failure	Occur	Current Process Controls	Detec	R. P. N.	Action Priority	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	R. P. N.
						- Tweezers	4	- Specified tweezer	3	84	C	- Follow up PI, training and	Thanorm	Done		4	3	84
						- Handling	6	- PI	7	294	A	self insp.				4	4	112
	Swaging	HGA / ARM /	Swage push out	- Tear down	7	- Swage Base alignment	6	- Ram work	5	210	A	- Sensor detection	Decha	Done	7	2	3	42
		PCC		- Functional								- Locking shuttle PM by weekly	Decha	ref.		2	3	42
						- Wrong swage ball size	2	- Ram work	5	70	C	- ME sampling check	Decha	PM		2	4	56
						- Pressure	4	- Ramwork	10	280	A	- Daily audit pressure	Thanorm			1	2	14
						- Driver pin Alignment	6	- VMI check / Ram work	5	210	A	- Swage free ball twice a shift	Thanorm			3	3	63
						bent												
			Bent arm	- Bent flexure	5	- Driver pin speed	5	- No	10	250	A	- Audit driver pin speed	Decha	Done	5	2	4	40
				- tear down		- Clamping force	4	- Clamping force spec	4	112	B	- Torque calibration by daily	Chirasak	ref.		4	3	84
												- Follow up PI, training and insp.	Thanorm	PI		3	3	63
												- PM add for clampling audit	Decha			3	2	42
			Damage pcc	- Failed ET	3	- Handling	4	- PI	7	84	C	- Training and self inspection.	Thanorm		8	3	3	72
			Contamination	- Scratch Disc	7	- Raw material	6	- Audit incoming HGA	2	84	C	- Training and self inspection.	Thanorm		7	3	3	63
							2	- Cleanliness test	3	42	C	- Monitor HGAs cleanliness test	Shusak	Done		2	2	28
								- 85/85				data						
			Gap to arm	- Tear down	8	- Improper Load HGAs to	6	- PI	5	240	A	- Training and self inspection	Thanorm	Done	8	3	3	72
				- Functional/		arm												
Swage continue				Reliability		- Clamping Force	4	- Clamping force spec	4	128	B	- Torque calibration by daily	Chirasak	Done		4	3	96
			Head misalignment	- Drive functional	3	- Bent needle pin	6	- Naked eye check	8	144	B	- Shiftly check needle pin by	Thanorm	ref.	3	4	3	36
												shiftly		PI				
						- Clamping Force	4	- Clamping force spec	4	48	C	- Torque calibration by daily	Chirasak			4	3	38
												guage						
			Metal shaving	- Contamination/	7	- Driver pin Alignment	4	- VMI check / Ram work	5	140	B	- Swage free ball twice a shiftly.	Thanorm		7	3	3	63
				Scratch Disc		bent						- Implement bore brush cleaning	Teerakorn					

POTENTIAL

FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item HSA Process Responsibility U2 Product

Core Team U2 Team

FMEA Doc Number # U2 1302

Page 3 of 5

Prepared By Shusak R.

FMEA Date (On Jun ' 1998

FMEA Date (Re Dec ' 1998

Process Function and Requirements	Pocess Step	Key Process Inpot	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential cause(s) / Mechanism(s) of Failure	Occur	Current Process Controls	Detec	R.P.N.	Action Priority	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	R.P.N.
Head alignment	Alignment	HGA / Arm	Bent gimbal	- Failed Gimbal	7	- M/C set-up	2	- Daily calibration	3	42	C	- Training and self inspection	Decha	Done	7	2	3	42
Inspection	Inspection	Coil assembly		- Tear down														
			Head Misalignment	- M/C R&R	7	- M/C R&R	3	- M/C R&R	4	84	C	- SPC($\bar{X}$ & R)	Shusak	Done	7	3	1	21
												- Triggering yield	Shusak					0
			Broken wire	- Failed ET	8	- Mis handling	2	- PI	4	64	C	- Self inspection training	Thanorm		8	3	3	72
				- Tear down														0
Wire preparation	Prepasewire	HGA / PCC	- Broken wire	- Failed ET	8	- Raw material	4	- HGA incoming inspection	3	96	C		Thanorm	Done	8	3	3	72
				- Tear down		- Worn out tweezer	4	- Specified tweezer	4	128	B	} Self inspection	Teerakorn			2	3	48
						- Workman ship	5	- PI	4	160	B		Thanorm			3	3	72
			- B/G	- Tear down	7	- Handling	6	- Hold unit in fixture	5	210	A	Training self inspection	Thanorm	Done	7	3	3	63
				- Scratch Disc														
Reflow soldering	Soldering wire	HGA / PCC pad	- Solder Briding	- Short circuit	6	- Solder Pad dimension	3	- Vendor controls	8	144	B	- Feedback vendor for C/A	Verawat	Done	6	2	4	48
						- Solder tip	2	- PM/Control	6	72	C	- Limit the tip life time to be	Decha	ref.		2	2	24
												16,000 pads		PI				
			- Cold Solder	- Intermittent Drive	8	- Reflow temp profile	4	PM control	5	160	B	- Self audit the temp parameter	Thanorm		8	2	3	48
				Fail														
						- Solder tip damage	3	PM Control	6	144	B	- Limit the tip life time to be	Decha	Done		2	3	48
												16,000 pads						
												- Self audit the temp parameter	Thanorm					
			- Solder splash	- Intermittent short	8	- Temp profile	4	PM control	5	160	B	- Self audit the temp parameter	Thanorm		8	2	3	48
						- Solder Volumn too high	5	Vendor control	6	240	A	- Implement solder screening plate	Senoko			2	4	64
			- Incomplete solder	- Intermittent Open	8	- Not enough solder	5	Vendor control	6	240	A	- Implement solder screening plate	Senoko		8	2	4	64
						- Insufficent reflow	3	PM Control for temp and	6	144	B	- Addition control for force, tip	Thanorm	Done		2	3	48
						parameter		time setting				life time audit						

POTENTIAL

FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item HSA Process Responsibility U2 Product

Core Team U2 Team

FMEA Doc Number # U2 1302

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Prepared By Shusak R.

FMEA Date (Ori Jun ' 1998

FMEA Date (Re Dec ' 1998

Process Function and Requirements	Pocess Step	Key Process Inpot	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential cause(s) / Mechanism(s) of Failure	Occur	Current Process Controls	Detec	R.P.N.	Action Priority	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	R.P.N.
			- Wrong soldering	- Failed ET	8	Workmanship	3	Visual aid	4	96	C	Self Inspection / Training	Thanorm	Done	8	3	2	48
			wire	- Tear down														
			- Broken wire	- Failed ET	8	- Handing	5	- Specify tweezer	4	160	B	- Training self inspection	Thanorm	Done	8	3	3	72
				- Tear down		- Worn out tweezer						- Shiftly visual inspection						
			- Damang PCC	- Failed ET	8	- Wrong reflow M/C set u	4	- Time set-up	4	128	B	- Additional tip life cycle	Decha	Done	8	2	2	32
			(burnt PCC)					- Temp set-up				limitation (16,000 pads)		ref.				
												- Tip force specify	Shusak	PI				
			- B/G	- Failed gramload	7	- Handing	6	- Hold unit in wip	5	210	A	- Training sell inspection	Thanorm		7	3	3	63
HSA cleaning	HGA / ARM	- HGA / ARM	- B/G	- Failed G/L	7	- Shock load from	5	- Remove bad cleaning	4	140	B	- Add PM on cleaning rack	Decha	Done	7	3	2	42
			- B/F	- Tear down		load/ unload temp		rack				- Standardize cleaning rack	Shusak	ref.				
				- Disc scratch		- Worn out cleaning rack	6		4	168	B			PM		3	2	42
						- cleaning rack design	4		4	112	B	- Modify cleaning rack	Shusak	Done		3	2	42
			- Contamination	Disc scratch	5	- M/C wrong set-up	5	- Audit set-up parameter	5	125	B	- State in ti by shiftly audit	Apidee		5	3	2	30
						- Cleanliness of cleaning	4	- Cleanliness test	5	100	B	- Add surfactant contamination				3	3	45
						soluble		- NVR										
								- Cl										
								- Silicone										
			- Damage PCC	Drive Functional	3	- Improper lock PCC	5	- Remove bad cleaning rack	2	30	C	- Add PM on cleaning rack	Thanorm	Done	3	3	2	18
			- Broken wire	Failed ET	8		5		2	80	C				8	3	2	48
G/L Inspection	Remove comb &	HSA	- B/G	Failed G/L	7	- Handling load /	4	- VMI	5	140	B	- Trainning handling method	Thanorm	Done	7	3	3	63
	head guard		- B/F			unload comb head												
						guard												

POTENTIAL

FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item HSA Process Responsibility U2 Product

Core Team U2 Team

FMEA Doc Number # U2 1302

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Prepared By Shusak R.

FMEA Date (Ori Jun ' 1998

FMEA Date (Re Dec ' 1998

Process Function and Requirements	Process Step	Key Process Input	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential cause(s) / Mechanism(s) of Failure	Occur	Current Process Controls	Detec	R.P.N.	Action Priority	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
														Actions Taken	Sev	Occ	Det	R.P.N.
	Measure	HSA	- B/F	Failed G/L	7	- R&R correlation	4	- Shiftly tester stability chec	4	112	B	- Monthly R&R correlation	Decha	Implement	7	3	3	63
				tear down				(STD unit)										
						- Load cell damage	3	VMI	5	105	A	- PM to check the critical area	Decha	Done	7	2	3	42
												- Life time fixed to be a month	Decha					
						- Head separator	3	VMI	4	84	C	- Separate area of bad head			7	2	2	28
						comb position bent						separator and immediately	Thanorm					0
												destroy						
ET	Measure	HSA	Failed ET	- Functional test	8	- Head failure	5	- 100% test	2	80	C	- FA on top 5 major failures.	Teerakorn		8	3	2	48
				- Tear down		performance						- Incoming inspection	Thanorm	Done		2	2	32
						- PCC pescamp						- Training self inspection	Thanorm	Done		3	2	48
						- Damage coil						- Triggering yield	Shusak	Done		2	1	16
			B/G	- Drive functional	7	- Handling during	4	- No	10	280	A	- Modify test fixture and	Decha	Done	7	3	2	42
						testing						shipping nest locking						
												- Training and self inspection.		Done				
DET	Measure	HSA	Failed DET	- Scratch disc	5	- Cartridge out of position	3	- Sampling audit at DET	5	75	C	- FA on the top major defect	Teerakorn		5	3	3	45
								test				- Training and self inspection.	Thanorm					
						- B/F , B/G	4	- PI	4	80	C	- Training how to handling units.	Teerakorn	Done	5	3	3	45
												and self inspection.						

Appendix III.

Appendix -1

Process Control Plan

Model:	Part Name:	Part No.	Customer Name:	Prepared:	Confirmed:	Approved:	Date:	Rev.
	Operational Symbol							
	MFG. opn.	MFG. Insp / Test	QA. Audit / Test					
	○	▭	□					

Process Flow Opn.	Operation Name	Facilities / Equipments Required	Check Points				Sampling				Trigger System		
			Calibration	Maintenance	Product Characteristics / Process to be audited	Spec.	Sampling Plan (Qty / Freq)	Recording Method	Responsible Person	Tool or checking Method used	Limits	Light Color	Responsible Person

Responsible person: ▭ Technician ○ MFG. Operator △ QC Inspector or Auditor

VITA

Shusak Rattanasasivimon was born on August 11, 1964 in Burirum province, Thailand. He obtained his Bachelor's Degree in Mechanical Engineering from Adamson University in 1988. He has started working at Seagate Technology Thailand in 1989.In the past Ten years experience with Seagate Technology, his job has been resolving day to day technical engineering issues, planning and organising. His current position now is Senior Manager of new product development engineer. In 1997; He was selected to be Seagate scholarship student to pursue his graduate study in Master Degree of Engineering Management at The Regional Centre for Manufacturing Systems Engineering at Chulalongkorn University and University of Warwick (UK).