Chapter 4

System Analysis of the Case Study

The purpose of this chapter is to look into how standard time estimation system works and to determine what product data required as an input in order to arrive at the standard time. The standing point of the thesis is to utilize historical product data. The rationale is based on the fact that most standard time estimation for PSUs involves modifying existing process plan instead of studying from scratch. Accordingly, patterns of time estimation in existing products are applicable to a new design. This refers to as the variant approach in process planning

Instead of having to create new process route every time for every new orders in the PSU product line. the solution first should aim at rapid time estimation by providing standard process plan. Every standard process plan is associated with a set of product design characteristics that can be used to determine the possible standard time. After the standard process plan is designed therefore it is important to determine what these common product data are.

4.1 Standard Process Plan Preparation

No.		ENG DEPARTMENT		
THE CASE STUDY NAME		Approved	Checked	Charged
STANDARD TIME CALCULATION FORM				

REV No		**PRODUCT**		**DATE**	
FG CODE		**CUSTOMER**		**CATEGORY**	

PROCESS	Insert Q'ty	Unit Cost (Bht)	AI Cost (Bht)	Std Time (Min)
1. Auto Insertion				
- Axial				
- Radial				
- Special Radial				
- Chip				
- SOP				
- Special SOP				
TOTAL			(A)	(C)

PROCESS	Net RU	Coefficient	Std Time (Min)	Std cost depend on The Company Std Cost 2002	
2. Manufacturing				Manufacturing Time Coeff.	1.00
- Pre Process				Packing Time Coefficient	1.00
- Heat Sink				Inspection Time Coefficient has 3 kinds	
- Manual Insert				- Easy	0.80
- Soldering				- Normal	1.00
- Repairing				- Difficult	1.20
- Packaging				Wage rate	Bht/Min
TOTAL				Standard Production Output	
3. Packing				1. Standard time	Min/Pc
4. Inspection				2. Manpower	Man
				- Cycle time	Min/Pc
				- Working time	480 Min 8 Hours
TOTAL				- Std. Output	Pcs/Shift
ADJUSTING COEFFICIENT				- Std. PQPH	PCs/Manhour

Process	Std Time (Min)	Coefficient	Record Time (Min)	Wage (Bht)
- Manual PWBA				
- Packing				
- Inspection				
TOTAL			(D)	(B)

(C)	**Total Mfg Std Time (Min)**	**Total Std Mfg Cost (Bht)**	(A)
(D)			(B)

Figure 4.1: Current Standard Time Estimation Form of the Case Study

From Figure 4.1 **ONLY** this form is documented in the standard time estimation process of the case study. Once the engineers receive Product Drawing and Parts list they can start filling in the form as shown above. However, the problem that they currently facing is that they are unable to show the new engineers how they came up with the numbers previously filled by past engineers in the first place. This is not at all practical since every newly employed engineer would need to find ways around the calculation in order to fill in the necessary gaps, as the result of this time is wasted and the data various every time engineers are employed. According to Figure 4.1, there are four main processes use in the production of PSU:

1) Auto-insertion (AI);
2) Manual-insertion (MI);
3) Packing;
4) Inspection.

The Auto-insertion process can be broken down further into three operations, where each operation uses particular machine, which are:

1) Axial auto insertion;
2) Radial auto insertion, and;
3) Chip auto insertion.

Manual insertion can also be broken down into six operations, which are:

1) Heat sink subassembly
2) Component preparation
3) Part insert
4) Soldering
5) Repairing
6) Assembly

What missing in the current standard estimation form as shown in Figure 4.1 is, firstly, the detail of what tasks are composed in each operation. The development of standard process plan depends on both the knowledge of domain experts and the product history. An effective approach is first to analyze the product database for standard process plans and then to use expert opinion on process plans and time estimation to consolidate the results. As a result, the author summarizes a Process Flow Diagram for PSU assembly in Figure 4.2. Then, the author develops the standard process plan in more detail for the case study and assigns codes as in Figure 4.3 for more standard and simple future reference.

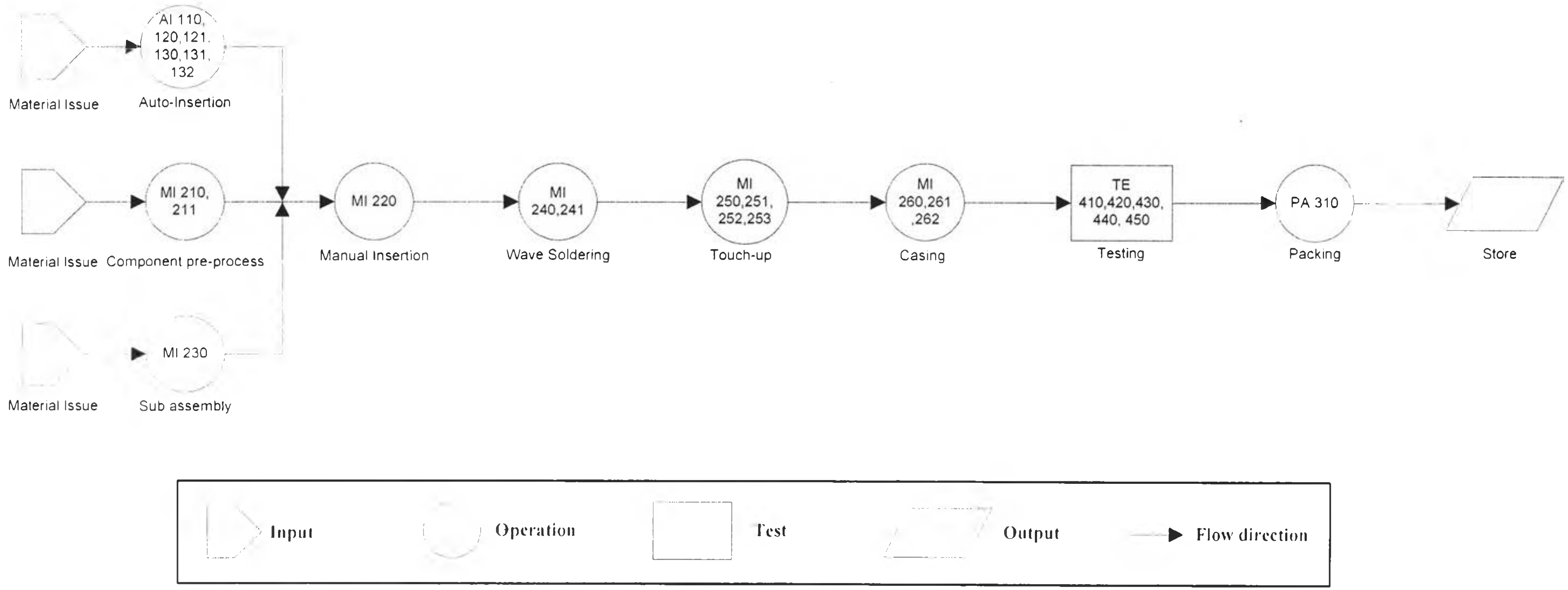


Figure 4.2: Establishment of Process Flow Diagram for Power Supply Unit Assembly

MODEL

DETAILED STANDARD TIME CALCULATION FORM							
NO	TASK	TIME REF.	SOLDER PT	INSERT PT	UNIT RU	NET RU	SEC
	1. Auto-Insertion						
AI-110	Axial Auto-Insertion						
AI-120	Radial Auto-Insertion						
AI-121	Special Radial Auto-Insertion						
AI-130	Chip Auto-Insertion						
AI-131	SOP Auto-Insertion						
AI-132	Special SOP Auto-Insertion						
	Sub Total						
	2. Manual Insertion						
	2.1 Component Preprocess						
MI-210	Lead Forming						
MI-211	Lead Cutting						
	2.2 Manual-Insertion						
MI-220	Manual Insertion						
	2.3 Sub-Assembly						
MI-230	Heat-Sink Sub-Assembly						
	2.4 Soldering						
MI-240	Printed Wiring Board Handling						
MI-241	Dipping Soldering						
	2.5 Touch-Up						
MI-250	Soldering Inspection						
MI-251	Touch-Up						
MI-252	Re-Soldering						
MI-253	Soldering Iron Handling						
	2.6 Casing						
MI-260	Printed Wiring Board Breaking						
MI-261	Bonding Barriers						
MI-262	Screwing Cases						
	Sub Total						
	3. Packing						
PA-310	Packing						
	Sub Total						
	4. Testing						
TE-410	Integrated Circuit Test						
TE-420	First Functional Test						
TE-430	Aging Test						
TE-440	Second Functional Test						
TE-450	Lot Numbering Stamping						
	Sub Total						

Figure 4.3: Proposed Detail Standard Time Estimation Form for Each PSU Model

4.2 Part Family Formation

From Figure 4.3, secondly, the detail of what parts are composed in each task is still needed. In order to be able to allocate the right components to the right task the author proposes part family formation since it would provide engineers a better working environment in the sense of filing and retrieving design characteristic (part feature), referencing products, recalling product information and common attributes.

In order to form group family, author analyzes historical Parts Lists of previous PSU models, which then matched against the proposed detailed standard time estimation form as shown in Figure 4.3 as well as seek for engineer approval prior arriving at 9 part families, which are separated into two main groups:

Group 1 – Electronic Components

Part Family 1 – Auto Insert Components

Part Family 2 – Pre-process Component

Part Family 3 – Manual Insert Components

Part Family 4 – Heat Sink Sub-Assembly

Group 2 – Utility Components

Part Family 5 – Printed Wiring Board (PWB)

Part Family 6 – Printed Wiring Board Supplement such as Auto machine glue

Part Family 7 – Soldering Materials such as solder and flux

Part Family 8 – Casing Materials such as barrier. Adhesive, case, and screw

Part Family 9 – Packing Materials such as plastic wrap, box, pallets, partition, etc

Electronic Components can be subcategorized to two groups 1) Semi-Conductor and 2) passive electronic components. Some components that are classified as semi-conductor for instance transistors, diodes, Integrated Circuits (IC), and couplers. As for passive electronic components there are resistors, capacitors, and coils. There are numerous types and designs of electronic components, which is more difficult to classify electronic components into groups when compare to the utility components that are not so much of. For this reason author shall in this case study direct attention to part family formation for electronic components.

Insertion is normally accounted as a primary task among other tasks in the PSU manufacturing. From author's hand on experience, observation and group meeting with those engineers at work and this is obtained: locating electronic components to whether the Auto or Manual Insertion Work-Center is considered to be most tedious due to amount of electronic components of usually more than hundreds. The reason is due to the scattering of the following main documents: 1) Material specification, and 2) Auto-Insert machine specification. In other word. there is no physical link between the design data and manufacturing data, as currently the link is usually in the head (knowledge). Therefore, the author shall design guideline for locating parts to Auto or Manual Insertion.

4.2.1 Parts for Auto-Insertion Process (AI)

Components that can be processed by Auto-Insertion must be electronic components that packed in taped rather like a chain of bullets or ammo pack (refer to Figure 4.4 for picture 2 and 3) however if the electronic components come in bulk (refer to Figure 4.4 for picture 1 and 4) then they will be passed along to the Manual Insertion process in which they will be inserted manually by man.

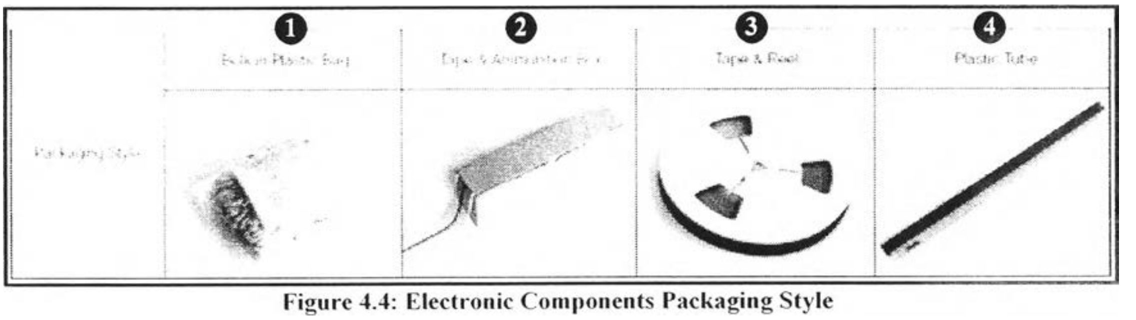


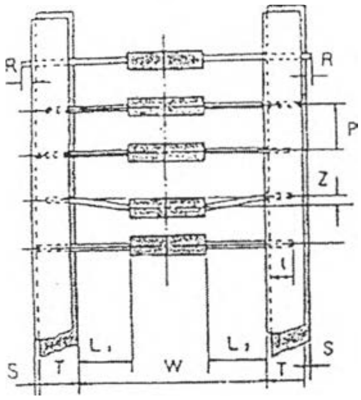
Figure 4.4: Electronic Components Packaging Style

Source: From website www.niec.co.jp

Beside the initial screening those electronic components size and dimension will have to be checked against machine capability for applicable components as this will double check whether or not those components are able to be processed by the specific machine, refer to sample component specifications. Author shall talk more about the concern components for each auto insertion task as follows:

4.2.1.1 Axial Auto-Insertion Machine

Axial Component Taping Specifications



Accuracy	I	II	III	Remarks
W	$26^{+0.2}_{0}$	$26^{+0.5}_{0}$	* $26^{+1.5}_{0}$	
	$(52^{+0.2}_{0})$	$(52^{+0.5}_{0})$	$(52^{+1.5}_{0})$	Note: 4.5
P	5±0.3		*5±0.5	*The cumulative pitch tolerance must not exceed ±2mm over 20 consecutive pitches.
L_1-L_2	Max. 0.2	Max. 0.5	Max. 1	
T	*6±1			
Z	Max. 1.0	*Max. 1.2		
R	0			*The ends of the component leads must not protrude.
t	*Min. 3.2			"t" is the length of the taped part of the taped part of the component lead.
S	*Max. 0.8			
Remarks	5mm pitch insertion			

Figure 4.5: Applicable Axial Components Taping Specification

Source: Panasonic Factory Solutions Co., Ltd.

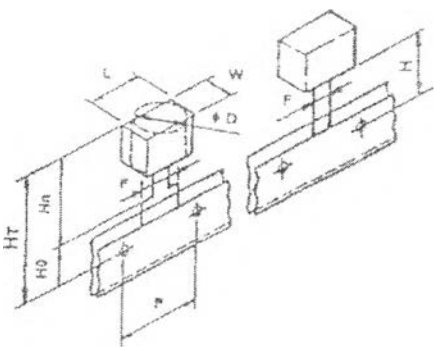
- **Task AI-110 Axial Auto-Insertion**

The applicable components for Axial Auto-Insertion are taped axial lead components such as:

- Carbon resistor
- Cylindrical ceramic capacitors
- Solid resistors
- Diodes
- Jumper wire and etc

N.B. for component dimensions, refer to Component Specification above.

4.2.1.2 Radial Auto-Insertion Machine



Component to be loaded		40, 62 or 80 feeder
Lead wire interval	(F)	2.5/5 mm
Taping pitch	(P)	12.7/15 mm
Component height	(H_O)	16 - 20 mm
Component height	(H)	18 - 20 mm
Component height	(H_T)	Max. 39 mm
Length	(L)	Max. 22.5 mm
Width	(W)	Max. 12 mm
Height	(Hn)	Max. 21 mm
Outer diameter	(φD)	Max. 13 mm

Figure 4.6: Applicable Radial Components Taping Specification

Source: Panasonic Factory Solutions Co., Ltd.

- **Task AI-120 Radial Auto-Insertion**

The applicable components for Radial Auto-Insertion are small/standard taped radial lead components such as:

- Transistors
- Ceramic capacitors
- Electrolytic capacitors
- Film capacitors
- Radial lead resistors and etc

N.B. for component dimensions, refer to Component Specification above.

Classification	Radial taping method		Change point
	Original shape	After radial taping	
Axial type			To be formed so that axial component will become pararadial component.
Float type			To be stage-formed so that the lead wire interval will match the pitch of the insertion machine.
Lead extension type			To be extended so that radial taping may be applied to the odd-shaped components.
Inline type			To be extended so that radial taping may be applied only to the lead wire to be guided at the time of insertion.
Potentiometer VR type			Change layout of component lead wire and extend lead wire.
False lead fitting type			Fit extra lead wire other than the current lead, and insert that lead by guiding.
Connector type (I)			Form multi-pin connectors by a combination of 2 pins or 3 pins.
Connector type (II)			Form more than 3 pin connectors by a combination of two 3 pins, 4 pins or 5 pins.
Casing type			Prepare a casing allowing for radial taping, and store odd-shaped component in there.
Sheet metal type			Provide taping for pressed sheet metal item.

Figure 4.7: Applicable Special Radial Components Taping Specification

Source: Panasonic Factory Solutions Co., Ltd.

- **Task AI-121 Special Radial Auto-Insertion**

The applicable components for Special Radial Auto-Insertion machines are odd-shaped/in-line taped radial lead components such as:

- Light Emitting Diodes (LEDs)
- Fuse clips,
- Light-touch switches
- Small stand-up resistors
- Connectors
- Resistor networks and etc

N.B. for component dimensions, refer to Component Specification above.

4.2.1.3 Chip Auto-Insertion Machine (or Surface Mounting Machine, SMT)

Parts	Outer appearance	Size			Cassette Type	Vacuum nozzle				Head tact (sec)	X-Y tact (sec)
		X	Y	T		Standard	Recommended 1	Recommended 2	Recommended 3		
1.0×0.5 C.R		1.0	0.5	0.3–0.5	8 x 2	Ref. SS	NA (Not applicable)	Ref. SA	Ref.SA	0.1	0.1
1.6×0.8 C.R		1.6	0.8	0.4–0.8	8 x 4		Ref. MA	Ref. MA	Ref. MA		
2×1.25 C.R		2.0	1.25	0.4–0.8	8 x 4						
3.2×1.6 C.R		3.2	1.6	0.4–0.8	8 x 4	M	M	M			
SS mini mold Tr		1.25	2.0	0.9	8 x 4	Ref. SS	Ref. MA	Ref.MA			
Mini mold Tr		1.5	2.9	1.1	8 x 4	M	M	M			
Mini power Tr		2.6	4.5	1.5	12 x 8	L	L	L	L	0.12	0.12
Tantalum capacitor A		3.2	1.6	1.6	8 x 4	M	M	M	Ref. MA	0.14	0.14
Tantalum capacitor B		4.7	2.6	2.1	12 x 4				L		
Tantalum capacitor C		6.0	3.2	2.5	12 x 8	L	L	L			0.3
Tantalum capacitor D		7.3	4.3	2.8	12 x 8						
Al electrolytic capacitor S		4.3	4.3	5.4	12 x 8						
Al electrolytic capacitor L		6.6	6.6	5.4	16 x 12	LL	LL	LL	LL	0.16	
Trimmer potentiometer		4.5	3.8	1.6–2.4	8 x 4	L	L	L	L	0.14	0.14
Trimmer potentiometer (Core open)		3.7	3.0	1.6	12 x 8						
Trimmer potentiometer (Taper open)		4.8	4.0	3.0	12 x 8						
Trimmer capacitor (Flat type)		4.5	4.0	3.0	12 x 8						
Trimmer capacitor		4.5	3.2	1.7	12 x 8	LL	LL	LL	LL		
IFT coil		4.8	4.8	4.9	12 x 8						
Film capacitor		7.3	5.3	3.25	16 x 8						
Light touch SW		6.2	6.2	2.0	12 x 8						
		8.0	6.5	3.5	16 x 8						
Cylindrical chip		2.0	1.25	1.25	8 x 4	Melf	Melf	Melf	Melf	0.16	0.2
Cylindrical chip		3.5	1.4	1.4	8 x 4						
SOP 8P		4.5	6.5	1.5–2.5	12 x 8	L	L	L	L	0.14	0.1-
SOP 14P		8.7	6.1	1.5	16 x 8					0.12	0.2
SOP 18P		11.7	10.5	2.4	24 x 12	LL	LL	LL	LL		
SOP 28P		17.8	10.4	2.4	24 x 12	LLL	LLL	LL (*1)	LLL	0.12	0.2
SOJ 28P		18.1	8.6	3.3	24 x 12						
PLCC 15 x 12 (32P)		15.0	12.0	3.5	24 x 16					0.14	
TSOP 44P		13.4	11.8	1.1	32 x 16					0.16	
QFP 22 x 22 (84P)		22.9	22.9	2.5	44 x 32						
PLCC 20 x 20 (52P)		20.0	20.0	4.5	32 x 24					0.25	0.3
QFP 32 x 32 (160P)		32.0	32.0	3.7	44 x 40					0.3	
PLCC 30 x 30 (84P)		30.2	30.2	4.3	44 x 36					0.5	0.5
*2 BGA/CSP (Option)		up to 7	up to 7	0.5		L				0.5	0.5
		7-10	7-10	-		LL					
		10–14	10–14	4.0		LL					

Figure 4.8: Applicable Chip Components Taping Specification

Source: Panasonic Factory Solutions Co., Ltd.

- **Task AI-130 Chip Auto-Insertion**

The applicable components for special Chip Auto Insertion machines are taped chip components that are Leadless (legless) component or the component with less than 4 legs such as:

  - Carbon resistors
  - Transistors
  - Tantalum capacitors
  - Electrolytic capacitors
  - Trimmer potentiometer
  - IFT coil
  - Film capacitors
  - Light touch switch
  - Cylindrical chip and etc

- **Task AI-131 SOP Auto-Insertion**

The applicable components for special Chip Auto Insertion machines are taped chip components that are component that have legs from 4 up to 32 legs.

- **Task AI-132 Special SOP Auto-Insertion**

The applicable components for special Chip Auto Insertion machines are taped chip components that are component that have legs from 4 up to 32 legs.

N.B. for component dimensions, refer to Component Specification in Figure 4.8

4.2.2 Manual-Insertion Process (MI)

- **Task MI-220 Manual-Insertion**

As author has already mentioned above under section 4.3.1, electronic components that come in a packet of bulk refer to Figure 4.4 picture 1 and 4 would be left to handle manually in Manual Insertion process. On the other hand, those components of picture 2 and 3 would also be handled by hand in the Manual Insertion process if their specifications do not match the machine's capability.

- **Task MI-210 and MI-211 Component Pre-process (Optional)**

Some components are to be handled before insert manually such as:

  - Lead cutting
  - Lead forming

- **Task MI-230 Heat-Sink Sub-Assembly**

Unlike other electronic components, heat-sinks are being assembled prior stuffing on the main Printed Wiring Board (PWB).

4.2.3 Guide line for locating Parts to Auto or Manual Insertion

Author has collected relevant data and information of the Task-110 through to Task MI-230 (Section 4.2.1 – 4.2.2) but in order to provide the reader a much less complicated overview of the classification, hence author simplified detailed description with the use of process flow diagram as shown in the following few pages.

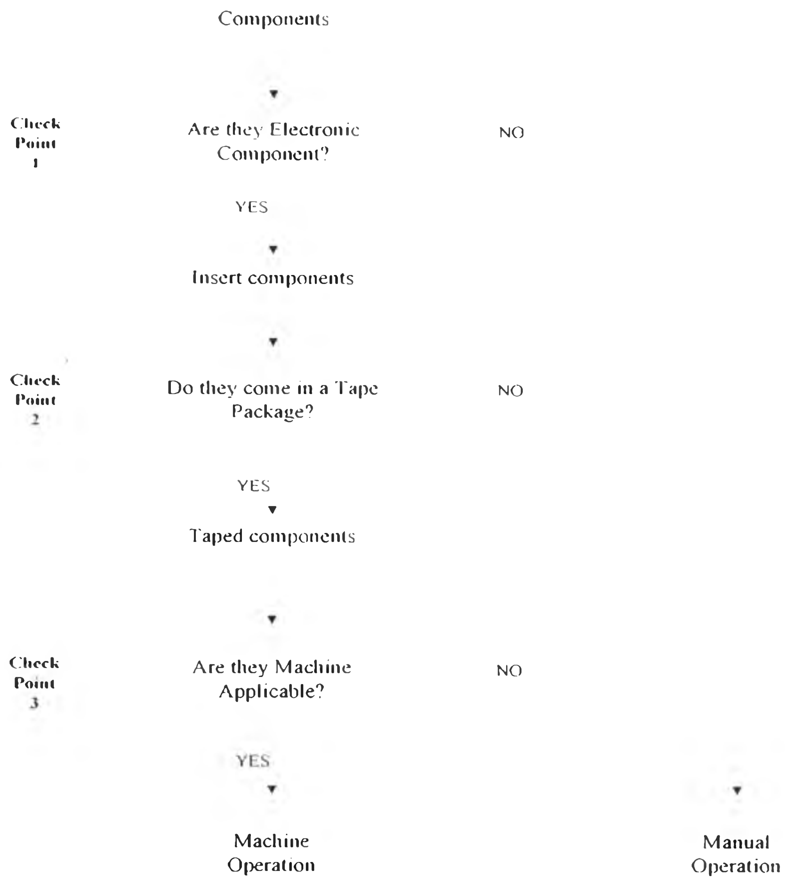


Figure 4.9: Establishment of Guideline for Locating Parts to Machine or Manual Operation

STEP 1 – Once the engineer receive Parts-List, engineers will need to perform a primary check to see that they are an electronic components and not utility components (such as solder, flux, glue, screen, nuts and bolts and etc) in which they are then passed to the following STEP 2.

STEP 2 – A secondary check is for components package, to see if they come in bulk or taped (Ammunition packaging), if the package does comes in bulk of individual components then they can only be inserted manually by hand, thus passing to Manual Insertion, while ammo package they are directed to Auto Insertion machine, however, further inspection shall be carried out.

STEP 3 – Further check upon the ammo package is to check against machine's capability to see if the components that come in ammo pack can still be inserted by machine. if not they will be redirected to Manual Insertion work center.

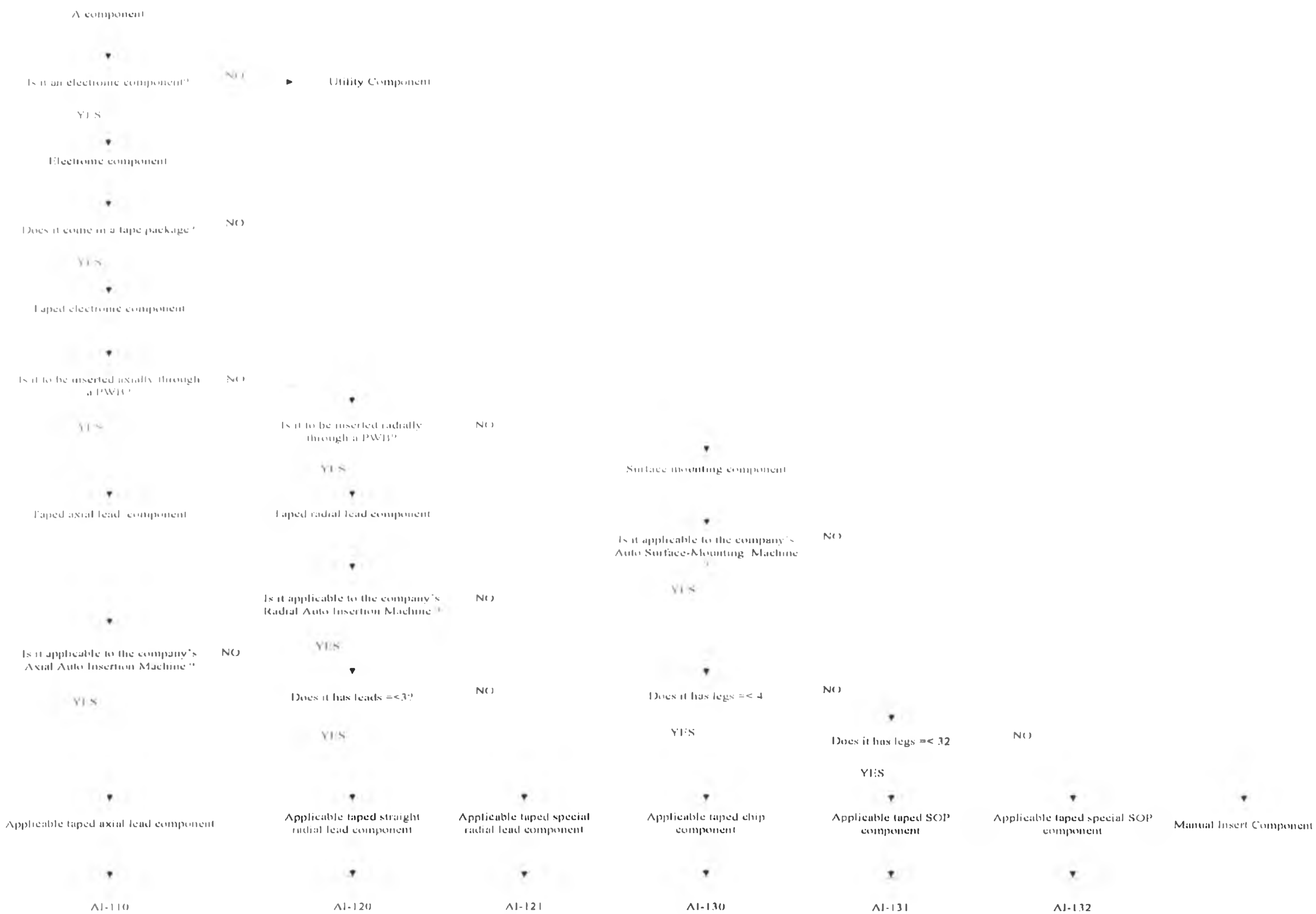


Figure 4.10: Establishment of Detailed Process Flow Diagram (1)

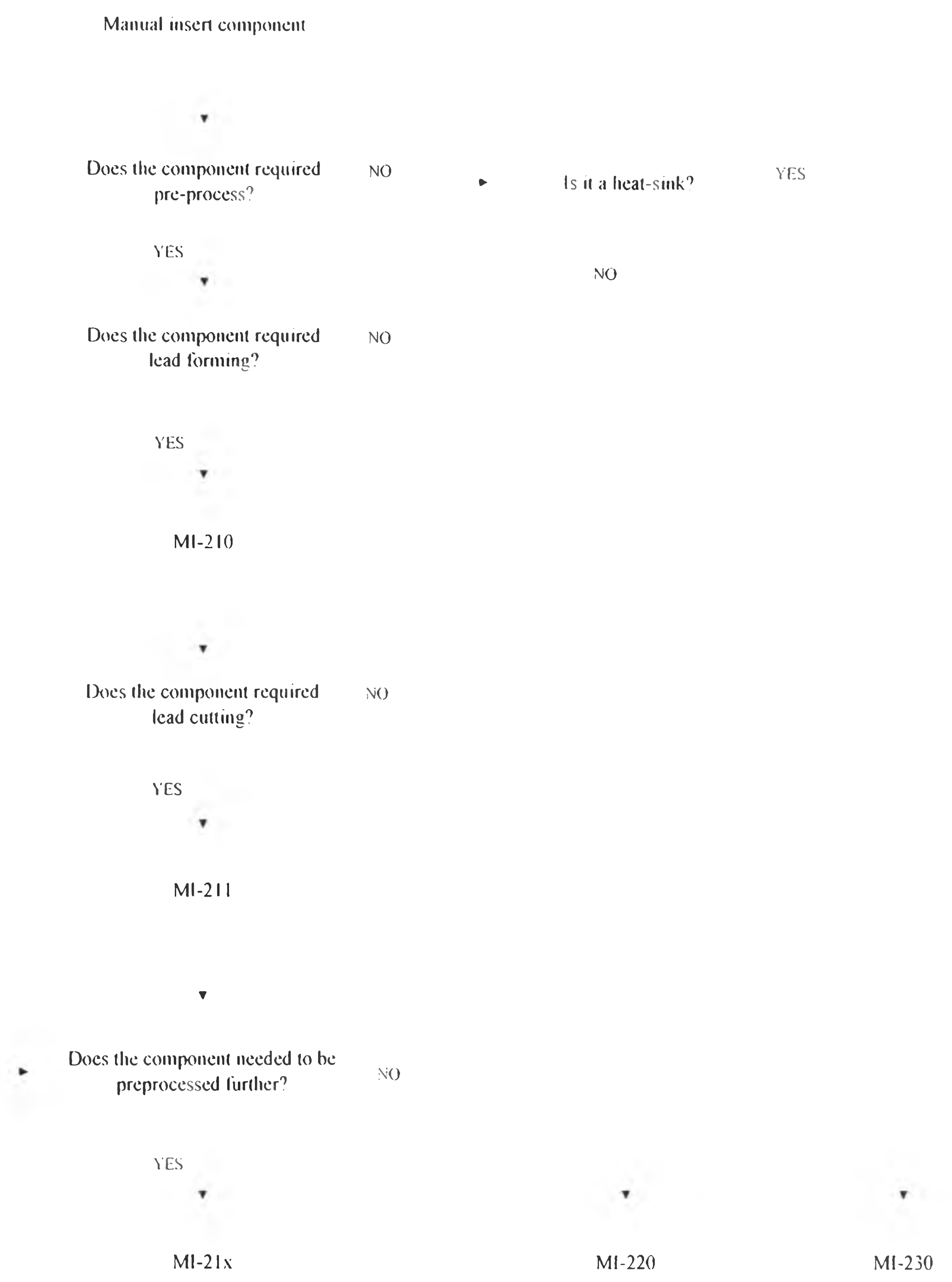


Figure 4.11: Establishment of Detailed Process Flow Diagram (2)

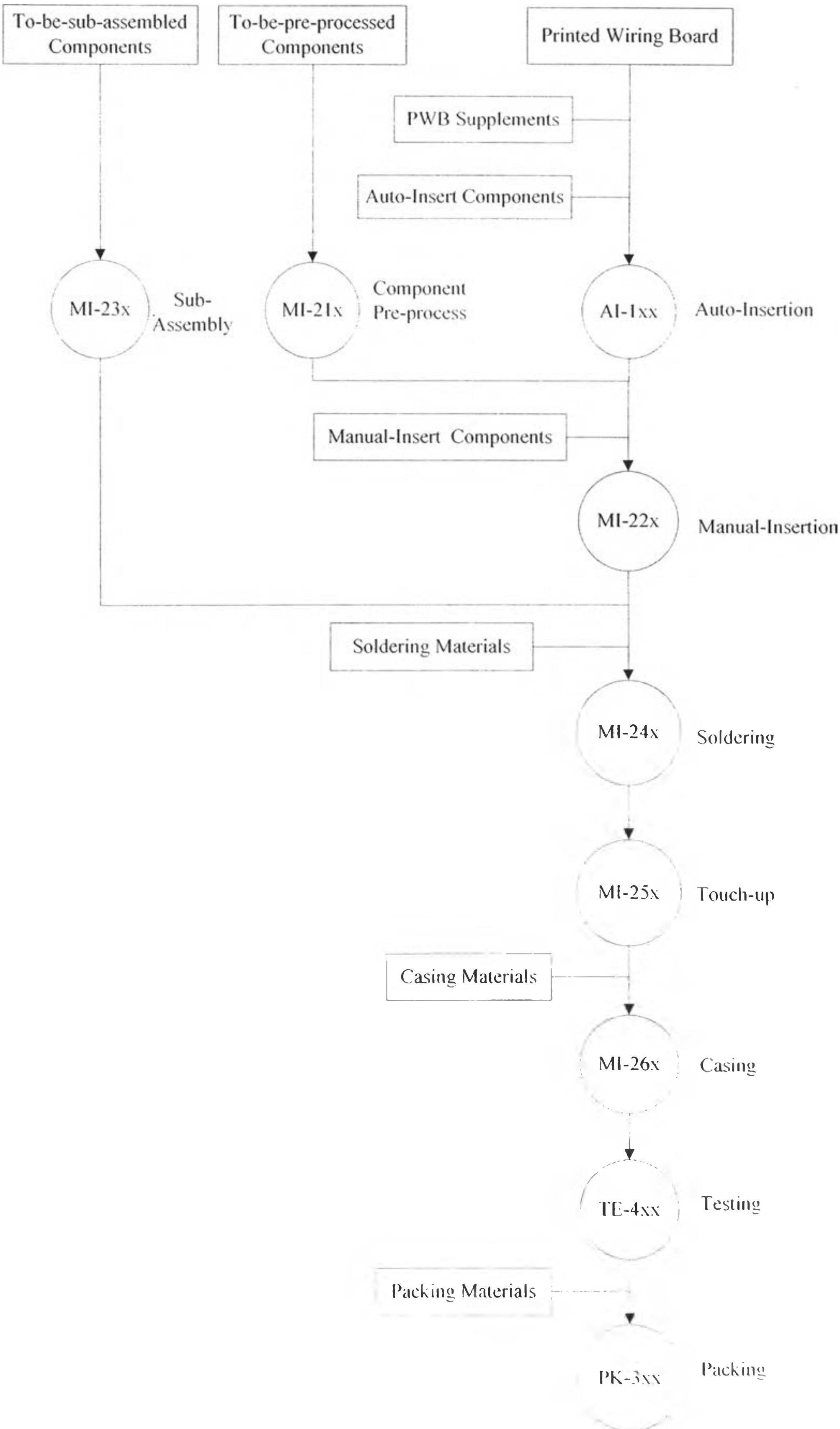


Figure 4.12: Establishment of Detailed Process Flow Diagram (3)

AI-110 AXIAL AUTO INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of Axial Auto Insert Solder Point =

Total No. of Axial Auto Insert Part =

AI-120 RADIAL AUTO INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of Radial Auto Insert Solder Point =

Total No. of Radial Auto Insert Part =

AI-121 SPECIAL RADIAL AUTO INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of Special Radial Auto Insert Solder Point =

Total No. Special of Radial Auto Insert Part =

AI-130 CHIP AUTO INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of Chip Auto Insert Solder Point =

Total No. of Chip Auto Insert Part =

AI-131SOP AUTO INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of SOP Auto Insert Solder Point =

Total No. of SOP Auto Insert Part =

AI-132 SPECIAL SOP AUTO INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of Special SOP Auto Insert Solder Point =

Total No. of Special SOP Auto Insert Part =

MI-220 MANUAL INSERT PART				
Location	**Part name**	**Part No**	**Code No**	**Solder Pt**

Total No. Of Manual Auto Insert Solder Point =

Total No. of Manual SOP Auto Insert Part =

Figure 4.13: Sample of Proposed Part Family Forms for Each PSU Model

4.3 Part Coding

From Figure 4.13, an introduction of Part Family Form has enabled future recall, which is beneficial when there is a need for certain component to be reused. Without reusing historical part data, it would have taken an extra time to match part to appropriate tasks. On the other hand, if there were no historical data of the parts, then engineers need to, thirdly, self classify the components by referring to product specification documents. As has already been mention in the previous chapter, not all the documents shall be available due to the amount of documents kept in the cabinet, document got lost on the way or not yet has been filed and lost in the system. Then there is a need to retrieve information directly from the suppliers for example through website or call center. But how to know which suppliers to search information from not knowing which particular supplier the product came from, since the company purchase component through a dealer and not direction from the supplier. The only information kept within the company's MRP database only specifies details of dealer but not of the supplier.

Therefore it is necessary to encourage engineers to keep detailed record of what they have searched in order to facilitate the next generation engineers and save them time from having to go through another long winded process in finding the same information that was once unknown over and over again and again from generation to generation. All in all keep record of what has been found rather than throw away information which could later on be useful for other engineers in the future.

Table 4.1: Proposed Material Specification Master List

The Company in Case Study					
Material Specification Master List					
Part Name________________					
Part Code	**Part No.**	**Part Maker**	**Task**	**File Location**	**Document Status**

Terms:

Part Name Common component name

Part Code Internal coding that is randomly formulated within the company

Part No. The serial number as generated by the original part manufacturer

Part Maker The name of the original part manufacturer (supplier)

Task Author proposed code AI-1xx, MI-2xx, PK-3xx, and TE-4xx

File Location Exact location of the part specification sheet

Document Status Whether the data has already obsolete

4.4 Product Database Evaluation

Transforming knowledge to data has increased the level of data amount and complexity, which is a threat since the data amount surely to grow in the coming near future. Therefore author proposes Relational Database Management System (Information Technology) as a computer-based instrument to help manage product data of current and future situation.

Table 4.2: Advantages and Disadvantages of Introducing Relational Database Management System

Advantages of Introducing Relational Database Management System	Disadvantages of Introducing Relational Database Management System
1. **Lower cost** - because of the availability of current resource at the company can be used to develop computerized relational database management system, DBMS, (e.g. using Microsoft Access and Visual Basic). 2. **Getting more information from the same amount of data** - because computer is more efficient at finding repetitive data 3. **Sharing of data more easily** 4. **Controlled or eliminated redundancy of document copies** - while one master is accessed through the network by authorised personal. 5. **Consistency** 6. **Integrity** 7. **Security** 8. **Increased productivity** 9. **Data independence**	1. **Larger memory storage** - hence ways to go around this is to only keep data that are necessary to standard time estimation process 2. **Greater complexity to non-literate users** - therefore user-friendly solution and training are needed so that engineers are able to perform standard time estimation with ease (availability issue). 3. **Greater impact of a failure when database are linked** – therefore data responsible person must be assigned (confidential issue) 4. **Though change is easier but recovery is more difficult** – thus only authorized person should have access to the master of document in making any changes. Also, it is important to be able to undo mistake, confirm data amendment, as well as, keep back up. (integrity issue)

As discussed in Table 4.2 Relational Database Management System approach (RDBMS) has both advantages and disadvantages, therefore it is important to utilize it to its most efficiency and prevent disadvantage from occurring, when designing a RDBMS system for standard time estimation process. The system development will further be discussed in the following chapter 5.

ต้นฉบับ หน้าขาดหาย