Jurnal Mekanikal
Jun 2002, Bil. 13, 95-117

MANAGEMENT AND CONTROL OF NON-DIRECT MATERIALS IN AN ELECTRONIC COMPANY

Hamidon Musa
Muhamad Zameri Mat Saman
Hau Lian Chuan

Department of Manufacturing & Industrial Engineering
Faculty of Mechanical Engineering
Universiti Teknologi Malaysia
81310 UTM Skudai, Johor.
Email: hamidon@fkm.utm.my, zameri@fkm.utm.my

ABSTRACT

The paper is based on a study aimed at establishing a management model used to control non-direct materials (NDM) in an electronic company. A set of procedures has been developed to address several problems associated with previous practices in the company. Examples of the problems are unavailability of procedures in NDM repair and scrap process, inefficiencies in tracking the actual quantity and investment cost of NDM and etc. A computer database system has been developed to assist the implementation of the management model.

Keywords: *Inventory Management, Inventory Control, Non-Direct Materials, Inventory Procedure, Computer Database.*

1.0 INTRODUCTION

The management model described in this paper has been developed to control 'non-direct materials' (NDM) in an electronic company which has been selected as a basis for the case study in the project.

The growth of business has led to fast expansion of the manufacturing capacity in the factory. More and more new production lines have been set up in a matter of months. Additionally, the layout of existing production lines has been changed quite frequently to improve production efficiency and space utilization. This has made NDM as a special and important category of materials to the company.

In the electronic company under study, the Manufacturing Engineering Department controls all items that fall under the category of NDM. Engineers from the department are responsible to determine the type and quantity of NDM required for each production line.

Currently, the department does have a control procedure for NDM. However, several weaknesses are found in the procedure as listed below:

i. Existing procedures are not able to effectively control the replenishment of NDM used in production lines.

ii. No systematic inventory control system is available to control the inventory level of NDM.
iii. There is no record showing the inventory status for both items used in production lines and those kept in store.
iv. No report can be conveniently generated to tell the investment cost of NDM in each production line. Actual expenditure of NDM is unknown.

There are other problems associated with the NDM issues faced by this company - cases like engineers having to search for NDM required for production lines, loss of NDM that are supposedly recorded as inventory in store, excess supplies of NDM in production lines, short supplies of NDM which caused inefficiency in production line and etc. All these problems need to be solved to increase the efficiency in managing the NDM. So based on that, the objective of this project is to establish better procedures to control and manage the NDM in the company.

2.0 OVERVIEW OF MATERIAL MANAGEMENT

There is hardly any published literature covering the management models for NDM. Many of the models that have been developed are based on direct materials. This is, perhaps, due to its direct requirement in manufacturing environment. Referring to the definition given in 3.0, NDM can be treated as indirect materials.

According to Ammer [1], managing indirect materials is similar to, but rarely as complicated as, managing direct materials. Thus, before establishing the management model for indirect materials, it is thought to be of advantage to review the existing management models that apply to direct materials. Existing management models for direct materials may provide useful guidelines on how to manage indirect materials.

As defined by Gopalakrishnan and Sudaresan [2], material management is the function responsible for the coordination of planning, sourcing, purchasing, moving, storing and controlling materials in an optimum manner so as to provide pre-decided service to the customer at a minimum cost. The scope covered by material management can thus be broadly identified to have the following three functions; material planning and control, purchasing, and store and inventory control.

Materials planning and control is done based on the revenue forecast and production scheduling. As for purchasing, Magad and Amos [3] stated that purchasing function involves obtaining the materials and services required by production.

Store control involves physical control of materials, preservation of stores, maintenance of stock records, proper location and stocking. On the other hand, inventory control is a coordinated rule for routinely answering the questions of

when to order and how much to order [4]. It covers aspects like setting inventory levels, ABC analysis, fixing economical ordering quantities, setting safety stock levels, inventory cost analysis and reporting. Several inventory control systems, such as Q system, P system and optional replenishment system by several authors have been reviewed [1, 2, 3, 4, 5].

3.0 NON-DIRECT MATERIAL (NDM)

NDM is a unique term used in the company. This is in addition to two other normally used categories of materials also employed in the company, namely direct materials and indirect materials. Direct materials refer to those core materials used to manufacture finished products such as resistors, capacitors, diodes and ICs that make up a printed circuit board assembly. Indirect materials are those that need to be consumed to produce finished products such as solder wires and bars, solder paste, flux and others. NDM refers to a selected category of tools, equipment, operating supplies, inspection tools and handling devices that are used in the company to support daily production activities.

It is realized that the term NDM is rarely used outside the company to refer to such items as NDM. This is because materials are normally taken to mean consumable items only. However, in this study, the term NDM has been retained since the study has been commissioned to specially address the need for this particular category of materials.

Generally, NDM used in the factory are fairly standard. They can be easily grouped according to their functional purposes. The following shows six categories of NDM and its examples of products:

i. Hand equipment and tools such as cutters, torque screwdrivers, tweezers.
ii. Inspection tools such as 3X magnifier lamps, 10X microscopes.
iii. Operating items such as tables, chairs, anti-static card cases.
iv. Soldering station facilities such as soldering sets, fume extractors, hot air rework stations.
v. Storing and handling devices such as cabinets, conductive trays, part bins, magazine racks.
vi. Safety devices such as ear plugs, safety goggles.

4.0 PROJECT METHODOLOGY

There is no specific or straightforward management solution that can be adopted directly to overcome the present weaknesses related to NDM procedures. However, ideas and expectations from end-users who have practised the existing procedure will be very useful to identify areas of improvement.

In this study two survey methods, namely self-administered questionnaire and interview, are employed. Before designing the survey, related studies are

conducted to review some of the material management systems proposed in academic references. The existing material management procedures of the company are also examined. The purpose of these studies is to identify common material management procedures that can be adopted to formulate the new control procedure for NDM.

The participants selected for the survey are not limited to the company's own staff, but also include representatives from other companies in the same industry. Internally, the survey is aimed at obtaining ideas on the current procedures and to get their comments on recommendations to further improve the existing procedure. Externally, the survey compiles the practices on how other electronic-based companies manage the NDM. The collected data from the survey is examined in the analysis stage. The result of the analysis is expected to provide guidelines in establishing the procedure for NDM.

Finally, a computer database is created to assist the management of NDM. The database is specially designed based on the need of the newly established procedure. It is an important tool used to track the transaction of NDM. The database can also be used to conveniently generate reports on the inventory level in store, the quantity used in each production line and amount of investment incurred to purchase NDM for each of the production lines and plants. The summary of the project methodology is shown in Figure 1.

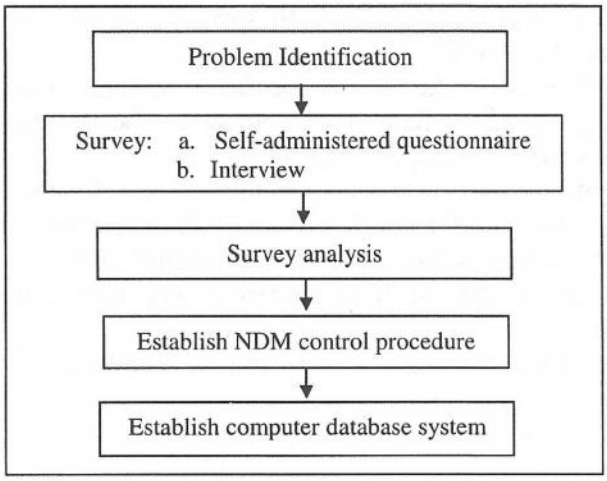


Figure 1 Project methodology

5.0 SURVEY OF EXISTING SYSTEM

5.1 Review of the Existing System

Currently, the control procedure for NDM covers the aspects of issuance and requisition only. However the procedure is not documented. There are yet no procedures developed for the receipt, return, repair and scrap of NDM.

Figure 2 illustrates the existing process flow of requisition, issuance and purchase of NDM. In the process, all NDM items are requested through the respective manufacturing engineer who is responsible for a specific project or production line. The required items need to be specified in a requisition form (NDM Requisition Form). The form is submitted to a centralized controller who has full responsibility over the NDM in the company. The controller processes the requisition form, initiates buying, issues required items upon receiving and updates all relevant records and documents.

After receiving the requisition form, the controller will assign a unique reference number. The reference number is also recorded in an issuance record (NDM Issuance Record). The number is used to track the issuance of NDM. By referring to the number in the record, the controller is able to check whether the required item has been issued or not.

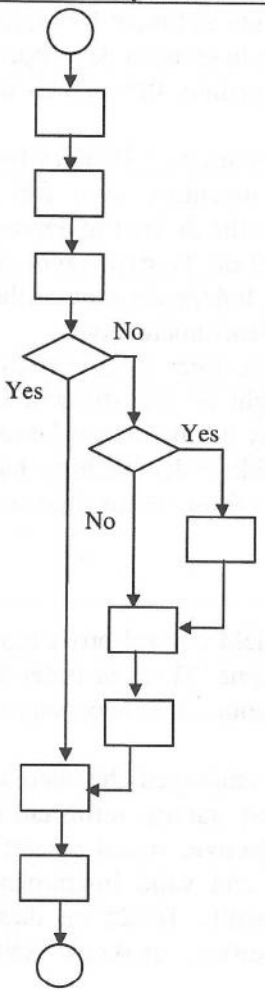
Symbol	Description
	Start All NDM must be requested through individual project's Manufacturing Engineer Manufacturing Engineer raises NDM Requisition form to specify the type and quantity of NDM required Centralized controller assigns reference number on Requisition form and processes the requisition Controller checks whether the stock required is available or not Controller checks whether the required stock is a new item or not Controller requests Manufacturing Engineer to provide specification of the new item Controller raises purchase requisition and gets approval to initiate purchase order and records the reference numbers of purchase requisition and purchase order in NDM Issuance record Controller receives purchased item from store Controller issues the required item to Manufacturing Engineer and gets his/her signature in Requisition form and records the transaction in NDM Issuance record Controller updates inventory status in store End

Figure 2 Process flow of NDM requisition, purchase and issuance

If the item is available in store, the controller can issue according to the requested quantity. Upon issuing, the balance of the item in store is updated in the inventory record. However, if the required item is not available, the controller has to buy the item by raising a purchase requisition. The reference number for purchase requisition and purchase order needs to be recorded in the NDM Issuance Record for tracking purposes.

In the existing practice, the controller can only manage to track partially the records of requisition and issuance. The above mentioned process flow has been practised for several months. However, the result is not encouraging. There is a lot of complaints received from manufacturing engineers and even the controller himself, indicating the problems and weaknesses of the procedure.

One such complaint is that when there is limited availability of NDM kept in store, the manufacturing engineers cannot replenish the item immediately because of items running out of stock. Another problem is that the controller needed to do a lot of tedious work in managing the documents and record, despite the fact that currently not all the NDM control procedures have been developed and implemented. Furthermore, he is only able to track partially the records of requisition and issuance.

Presently, there is no inventory control system that applies to NDM. In the existing practice, the controller determines the desired inventory level for a selected NDM. There is no systematic formula to calculate the desired inventory level and the quantity of the stock items is arbitrarily based on the experience of the controller. Similarly, no fixed reorder point is assigned. It depends a lot on the judgement of the controller to decide when to purchase replenishment stock.

Normally, the controller does not immediately place an order whenever the quantity drops below the set inventory level. It is thought as unjustifiable to purposely raise purchase requisition to buy a small quantity of one or two items. Instead, the controller will initiate order when a reasonable order quantity has been accumulated. Obviously, this is not applicable for those items that are urgently required.

5.2 Survey

There are several problems associated with the existing NDM control procedure. Relevant data needs to be collected to identify the problems. Thus, in order to gather more information relating to the NDM control procedure, it is necessary to conduct a survey.

In designing the survey questionnaire this study has employed the method recommended by Fink [6]. According to Fink, the best survey information systems have these six features; specific measurable objective, sound research design, sound choice of population or sample, reliable and valid instrument, appropriate analysis and accurate reporting of survey results. Based on these recommendations, questions are organized for both survey methods; self-administered questionnaire and interview.

5.3 Survey Result

Based on the collected questionnaire, respondents are not satisfied with the effectiveness of the existing NDM procedure (a mean rating of 2.3 out of a maximum possible score of 5). They have also been requested to identify several improvement areas that are thought to be important and urgent. Twelve such areas, covering the aspects of procedures, records and reports have been identified by the study. These areas serve as guidelines for developing the NDM control procedure.

As for the inventory control system, the respondents agreed that NDM exhibit a 'dynamic and risk' pattern in its supply and demand behavior. As defined by Gopalakrishnan and Sudaresan [2], the supply could be one-time supply (static) or a continuously repetitive one (dynamic) and the demand on its part could be totally known (certain), be known over a range of probable values (risk), or could be totally unknown (uncertain). For this pattern, several inventory models have been recommended. These models are modified and adopted as the new system to manage NDM in the study.

5.4 Interview

The interview is aimed at providing supplementary information on how other companies manage their NDM. The focus of the interview is to understand how they control the inventory of NDM.

Based on the six electronic-based companies that have been surveyed, most of the companies do not have clear inventory system to control the NDM. Out of these companies, three do keep inventory for certain categories of NDM. These materials consist of items required in manual soldering process. However, no fixed desired inventory level is established. The inventory levels are estimated based on individual experience. Out of these three companies, only one company applies fixed reorder points on inventories. The reorder point is determined based on the 'usage' of the particular item.

Two companies use computer system to track the transaction of NDM and another two companies manually record the transactions. Most of the companies allocate a store to keep NDM. But only two companies are willing to assign a dedicated resource person to manage the store.

6.0 NON-DIRECT MATERIAL (NDM) PROCEDURE

6.1 Overall Framework

The areas of improvement that need to be addressed in the project are summarized below:

i. Receipt procedure
ii. Requisition procedure for replenishment
iii. Requisition procedure for new line setup
iv. Issuance procedure
v. Expense procedure

vi. Investment cost for each project
vii. Inventory record in store
viii. Inventory record for each production line
ix. Return procedure
x. Repair procedure
xi. Scrap procedure

Of the twelve areas, only eight types of procedure need to be established (a to e and j to l). The other four consist of two expense reports (f and g) and two inventory records (h and i). The reports are documents showing the investment and issuance expenses of NDM while the records are used to track the store inventory status and existing quantity of NDM used in the production lines.

The general relationship between the procedures is shown in Figure 3. It starts with the requisition process and followed by the issuance process. If there is shortage in store, purchase requisition is raised. Subsequently, the purchased items are received and kept in store. If there are items that need to be returned from production lines, the return procedure is applied. Repair procedure applies on items that require repair only. For those obsolete or irreparable items, they will be disposed via scrap procedure.

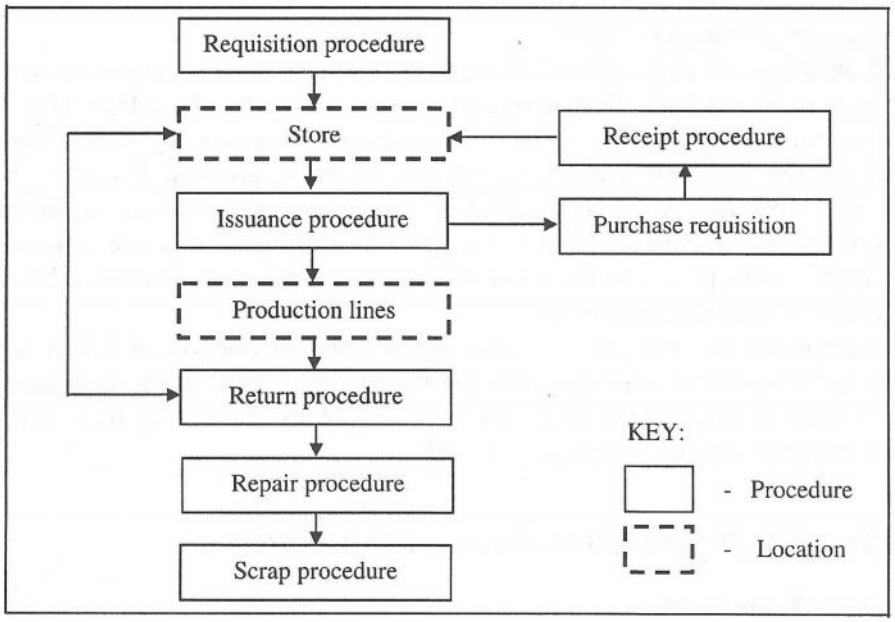


Figure 3 Relationship between procedures

6.2 Management and Control

The management model proposed in this study covers the existing procedures that have been improved and four completely new procedures that have been developed. The newly established procedures used to control the management of

NDM are presented in a form of flow chart. The detailed description of each transaction, the relevant documents required to process the transaction and the responsible parties are described in the flow charts as shown in Figures 4 to 9.

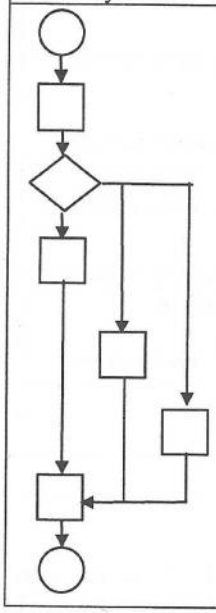
Symbol	Process description	Document	Owner
	Start		
	Fill up form and identify the reason for requisition	NDM requisition and return form	Individual line Manufacturing Engineer (Line ME)
	Check reason of requisition. Justify reason appropriately.		
	For line setup	checklist (if necessary)	Line ME
	Shortage in production lines		Line ME
	Missing item		Line ME
	Submit relevant documents to centralized coordinator	NDM requisition and return from checklist	Line ME and centralized controller
	End		

Figure 4 Process flow of requisition procedure

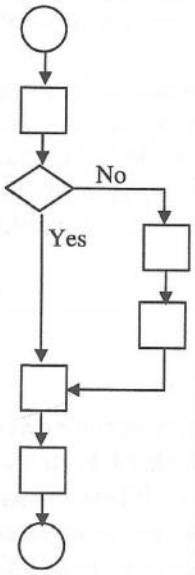
Symbol	Process description	Document	Owner
	Start		
	Receive form Assign reference no.	NDM requisition and return form	Centralized controller
	Check availability of stock	Store inventory record	Centralized controller
	Raise requisition	Purchase requisition form	Centralized controller
	Receive purchased items and update record	Delivery order Inventory record	Centralized controller
	Issue the required items Obtain requestor's signature	NDM requisition and return form	Centralized controller and line ME
	Update records	Store inventory record Issuance tracking record Line inventory record	Centralized controller
	End		

Figure 5 Process flow of issuance procedure

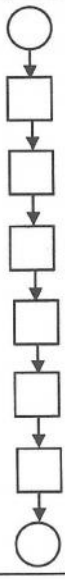
Symbol	Process description	Document	Owner
	Start		
	Receive (by store) Inform controller	Delivery order/invoice	Receiving personal
	Check and verify by signing Obtain PO number	Delivery order	Centralized controller
	Shift to non-direct material store and update record	PR tracking record	Centralized controller
	Update record and check who the requestor is	Store inventory record Issuance tracking record	Centralized controller
	Issue the required items Obtain requestor's signature	NDM requisition and return form	Centralized controller and line ME
	Update record	Store inventory record. Issuance tracking record	Centralized controller
	End	Line inventory record	

Figure 6 Process flow of receipt procedure

In the newly established procedures, only three types of forms are involved in the replenishment of NDM. These forms are the NDM requisition and return form, the facility job requisition form and the NDM scrap form. The NDM requisition and return form is a modification of the previous form. In the proposed system, the form can be used for both the requisition and return processes. Overall, the controller has to keep these forms as document records for tracking purposes.

Overall, the new procedures have standardized the process flow in managing and controlling the NDM. The procedures clearly spell out the responsibilities of respective owners and describe the inter-departmental relationship when dealing with the transaction of NDM. In other words, with the new procedures, it is expected that the efficiency of managing the NDM would be increased and routine problems prevented from happening.

7.0 COMPUTER DATABASE SYSTEM

There are many records that need to be maintained by the controller in the newly established procedure. All the records are important to keep track of both the current status as well as the historical data for each transaction of NDM. Thus, based on the newly established procedures, a specially designed computer database system is created using Microsoft Access 97. The database helps the controller to maintain the records more effectively. The system is also able to

generate reports indicating the investment cost of NDM as well as material status reports.

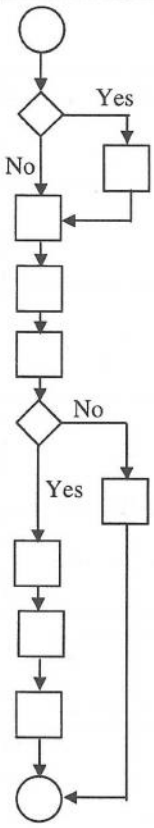
Symbol	Process description	Document	Owner
	Start		
	Check whether required item is new item		Centralized controller
	Line ME provides specification of new item to controller	Request for quotation	Line ME Centralized controller
	Raise requisition	Purchase requisition form (PR)	Centralized controller
	Submit to purchase dept.	PR	Centralized controller
	Source quotation (for new item only). Decide supplier	Quotation	Purchaser
	Obtain approval	PR	Centralized controller Department manager Finance manager
	Cancel purchase required Acknowledge requestor	PR	Centralized controller Requestor
	Initiate purchase order	Purchase order (PO)	Purchaser
	Record and update PO number and arrival time of the item Acknowledge requestor	Photocopy of PR PR tracking record	Purchaser Centralized controller Purchaser
	Receive required item		
	End		

Figure 7 Process flow of purchase requisition procedure

The basic functions of the database are summarized as follows:

i. Provides key information of NDM such as price, supplier, delivery lead-time, desired inventory level etc.
ii. Records the historical transaction for requisition and return of NDM.
iii. Keeps track the issuance and return record of NDM between store and production.
iv. Keeps track the purchase requisition issued to buy NDM and the receipt of the purchase items.
v. Provides accurate and updated inventory level of NDM in store and the existing quantity of NDM used in each workstation of production line.
vi. Reports the investment cost of NDM both in store and production line.

Upon entering the database, there are three categories of applications that can be selected under the NDM control menu; the data entry application that requires the controller to manually enter the data, the view report application, and the view record application.

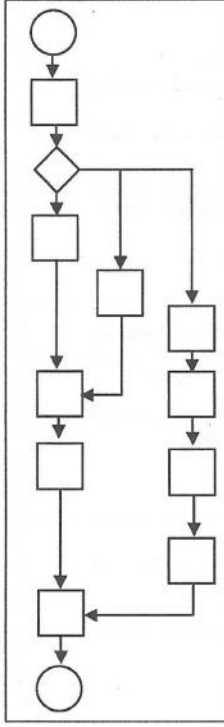
Symbol	Process description	Document	Owner
	Start		
	Fill up form and identify the reason for return	NDM requisition and return form	Line ME
	Check reason for return Justify reason appropriately		
	Product end-of-line (EOL)	Checklist (if necessary)	Line ME
	Excess item		Line ME
	Return for repair purpose		Line ME
	Submit document and item to controller	NDM requisition and return form	Line ME and centralized controller
	Assign reference number	NDM requisition and return form	Centralized controller
	Issue replacement item if stock is available	Store inventory record	Centralized controller
	Update record	Store inventory record Issuance tracking record	Centralized controller
	End	Line inventory record	

Figure 8 Process flow of return procedure

7.1 Data Entry Application

These applications are the NDM requisition and return, the NDM transaction and the PR tracking. Through these applications, the controller enters data manually into the database so that records and reports can be generated automatically. Thus, it is crucial to ensure that data is entered correctly in each application.

The NDM requisition and return database stores the records of requisition and return process that is initiated by requestors. Figure 10 shows the NDM requisition and return form. Data needs to be entered into several blank text boxes in the form. Thus, based on the requisition or return form submitted by requestors, the controller can easily enter the data into the database via this application. The historical records of requisition and return will be kept by this database.

Meanwhile, the NDM transaction keeps the historical data with respect to each transaction of issuance, receipt and return of NDM. The format of the application is illustrated in Figure 11. The controller has to enter relevant data once items are issued or returned.

After entering data for product identification (Product ID), line number (Line No.) and workstation description (Station), the controller can click the button for 'check store inventory', located at the bottom of the screen to check the inventory level in the store for a particular item. Figure 12 illustrates the format of store inventory record that will be displayed after clicking this button. Similarly, by clicking the button for 'check quantity in line', the controller can access the existing quantity of an item used in a particular workstation and production line. Figure 13 shows the format of the record that will be displayed after clicking this button.

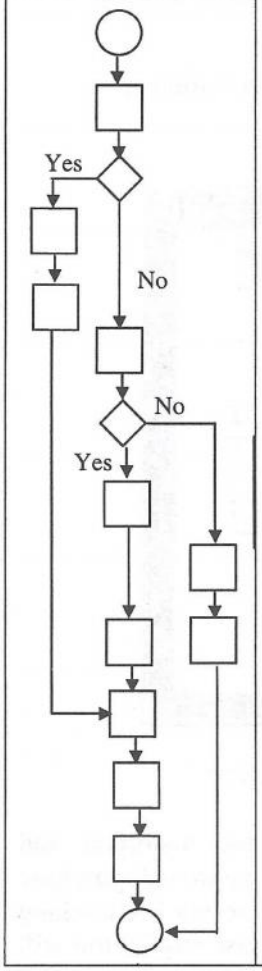
Symbol	Process description	Document	Owner
	Start		
	Receive item that needs repair	NDM requisition and return form	Line ME
	Check whether the item needs supplier's service		
	Apply purchase requisition procedure		Centralized controller
	Acknowledge requestor		Centralized controller
	Raise form and submit item to Facility Dept.	Facility job requisition form	Centralized controller
	Check whether the item can be repaired		Facility personnel
	Obtain required repair period		Facility personnel Centralized controller
	Raise form and scrap item	Scrap notice	Centralized controller
	Compile into records	Repair and scrap record	Centralized controller
	Receive repaired item		Facility personnel
	Keep item in store and update records	Repair and scrap record Store inventory record	Centralized controller
	Issue item (if necessary) and update records	Issuance tracking record Inventory records	Centralized controller Line ME
	End		

Figure 9 Process flow of repair and scrap procedure

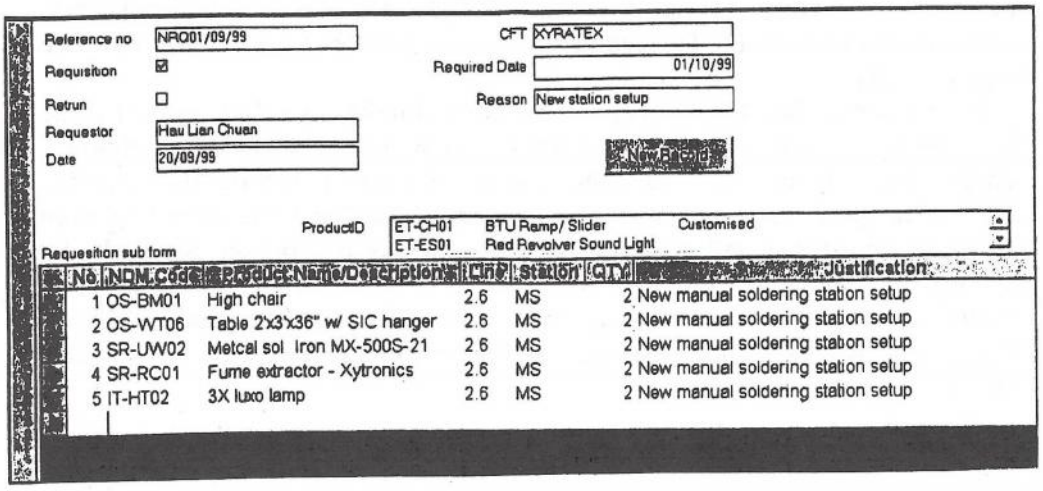


Figure 10 The NDM requisition and return application

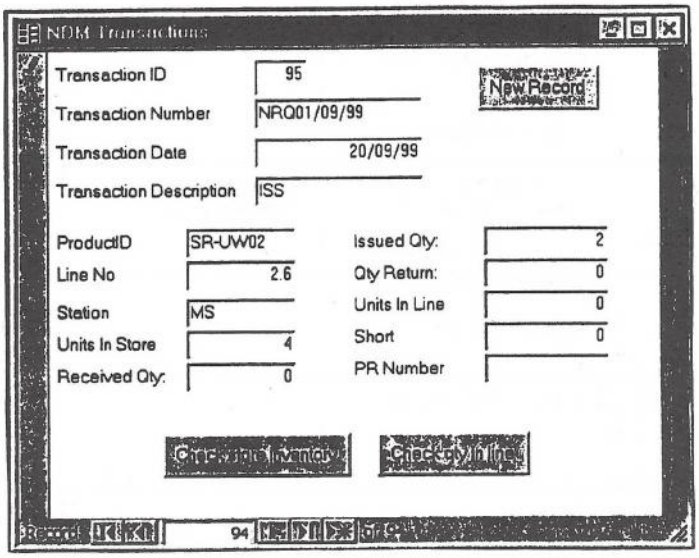


Figure 11 The NDM transaction application

The application also allows the controller to track the historical and outstanding records of purchase requisition. Based on the approved purchase requisition, relevant data is entered manually into the database via PR tracking application. The purchase order number for a particular purchase requisition will be used as tracking number. The format of the application is shown in Figure 14.

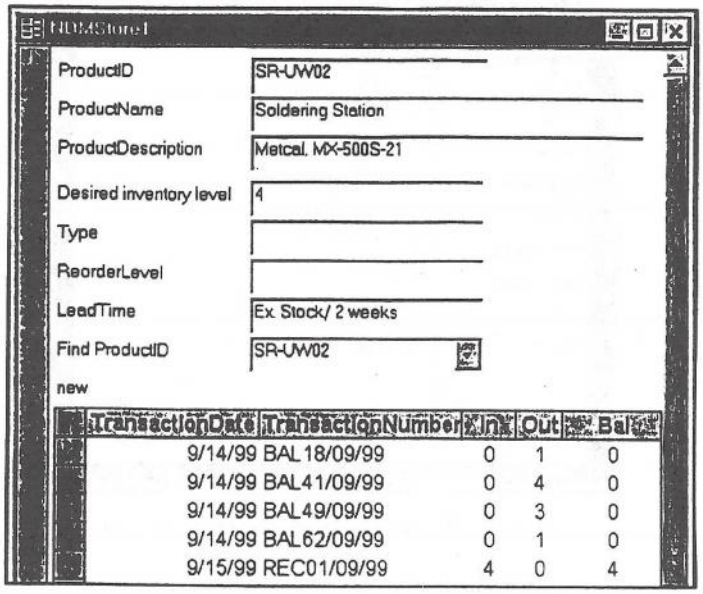


Figure 12 The store inventory record

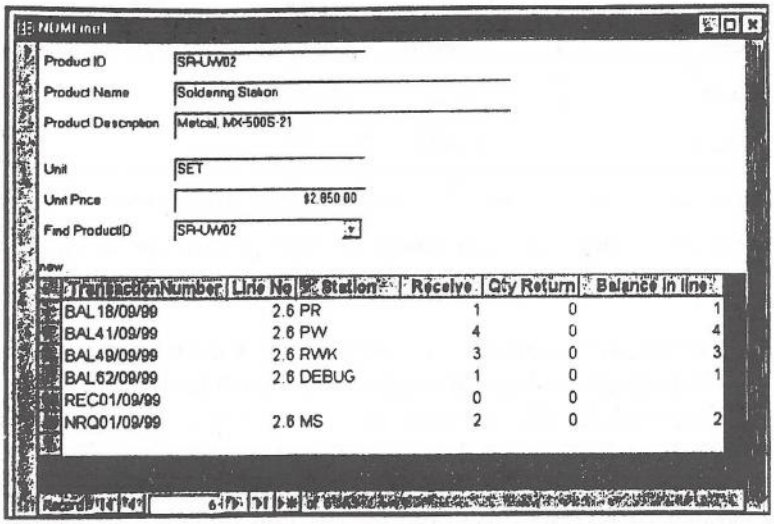


Figure 13 The line inventory record

7.2 View Report Application

Four reports can be generated automatically in this application. They are store inventory status, detail line inventory status, detail line inventory cost and overall line NDM investment report. The store inventory status report is a report indicating the quantity of items that are kept in the store. It also shows the total inventory costs of these items. The detail of the report is shown in Figure 15.

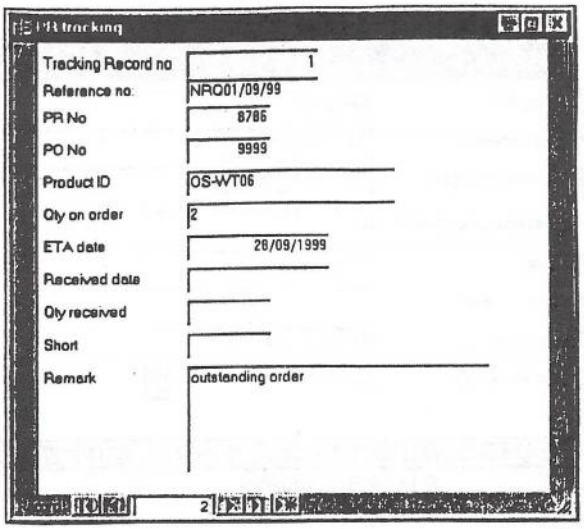


Figure 14 The PR tracking application

Inventory in store Report

ProductID	***Bal***	***Unit Price***	***Total***	***Total Invetory Cost***
IT-HT02	2	$330.00	$660.00	$6,646.00
SR-RC01	1	$286.00	$286.00	
SR-UW02	2	$2,850.00	$5,700.00	

Figure 15 Example of report indicating the quantity and costs of items kept in store

The detailed line inventory status report indicates the existing quantity of items used in the workstations of a particular production line. Figure 16 shows part of the report. Meanwhile, the detailed line inventory cost report indicates the investment costs of NDM in each station of a production line. Figure 17 shows a part of the report. Lastly, the overall line NDM investment report summarizes the total investment of NDM in each production line. Figure 18 illustrates the total investment of NDM in production line 2.6.

7.3 View Record Application

A total of three records can be viewed in this application. They are NDM transaction record, store inventory record and line inventory record. The first menu, the NDM transaction record actually stores the data entered via NDM transaction in data entry application. The data input via NDM transaction application is stored and shown according to the Product ID of NDM. Thus, the

Inventory In Line_Crosstab(quantity)1

Line No	ProductID	Total	All	CP	Debug	DEK	FVMI	HL	ICT	IP	Massy	MAssy(HL)	MS	Pack	PF	P.DEK	PR	Pre R	PW	QA	RWK	SI
2.6																						
	ET-CH01	1															1					
	ET-ES01	1						1														
	ET-IH01	1				1																
	ET-MH01	1																1				
	ET-SE01	3									1	2										
	ET-TE02	3									1	2										
	ET-TE03	3									1	2										
	ET-TE05	2										2										
	IT-HT02	10			1								2			1	1		4			1
	IT-KT01	4					4															
	IT-SH01	10					1										1			3	4	1
	IT-SH02	4					3													1		
	OS-BM01	21					3	4					2	1	1		1		2	4	3	
	OS-CH01	1												1								
	OS-LB01	1															1					
	OS-LB02	2				1		1														
	OS-SK01	1							1													
	OS-SK02	5					2		1								1			1		
	OS-WT06	15					4						2						4		5	
	OS-WT07	2															2					
	OS-WT08	5	1			1						1		1								1

Page 1 of 2

Figure 16 Example of report indicating the quantity of items used in the workstation of a specific production line

Line No	ProductID	Total	All	CP	Debug	DEK	FVMI	HL	ICT	IP	Massy	MAssy(HL)	MS	Pack	PF	P.DEK	PR	Pre R	PW	QA	RWK	SI
	OS-WT10	1																1				
	OS-WT12	1			1																	
	OS-WT15	1						1														
	OS-WT17	1				1																
	OS-WT18	24			1		3	1	2					1	6		2		4	3		1
	SH-DY01	7					4	1									1				1	
	SH-DY15	250	250																			
	SH-DY16	50	50																			
	SH-DY17	100	100																			
	SH-DY18	100	100																			
	SH-IH01	1				1																
	SH-WE01	1		1																		
	SH-WE02	1								1												
	SH-WF01	1		1																		
	SH-WT05	16	16																			
	SH-WT06	3	3																			
	SH-WT10	1				1																
	SH-WT13	10						10														
	SR-HT03	1																			1	
	SR-RC01	11			1								2				1		4		3	
	SR-UW02	11			1								2				1		4		3	

Figure 16 Example of report indicating the quantity of items used in the workstation of a specific production line (continue)

Inventory in line_Crosstab(Money)1

Line No	*ProductID*	*Total*	*All*	*CP*	*Debug*	*DEK*	*FVMI*	*HL*	*ICT*	*IP*	*Massy*	*MAssy(HL)*
2.6												
	ET-CH01	$35.00										
	ET-ES01	$120.00						$120.00				
	ET-IH01	$50.00				$50.00						
	ET-MH01	$3,050.00										
	ET-SE01	$60.00									$20.00	$40.00
	ET-TE02	$1,200.00									$400.00	$800.00
	ET-TE03	$300.00									$100.00	$200.00
	ET-TE05	$1,600.00										$1,600.00
	IT-HT02	$3,300.00			$330.00							
	IT-KT01	$740.00					$740.00					
	IT-SH01	$53,420.00					$5,342.00					
	IT-SH02	$13,640.00					$10,230.00					
	OS-BM01	$3,150.00					$450.00	$600.00				
	OS-CH01	$17.00										
	OS-LB01	$23.00										
	OS-LB02	$158.00				$79.00		$79.00				
	OS-SK01	$3.80							$3.80			
	OS-SK02	$30.00					$12.00		$6.00			
	OS-WT06	$2,700.00					$720.00					
	OS-WT07	$700.00										

Figure 17 Example of report indicating the investment cost of NDM in the workstation of a specific production line

historical transaction data of each item can be viewed under this application. The record can further be manipulated to generate other useful reports such as monthly NDM issuance report. The data in the record can be filtered and only those relevant issuance records will be published in the report. Figure 19 shows the format of the record for a Nikon 10X microscope.

The second menu, the store inventory record, is a collection of historical data for each NDM that passes through the store. Transactions, such as issuance of item from store to production, receipt of item from supplier or return of item from production lines, are captured in the record. The record also indicates the updated stock level in the store. An example of the record has already been shown in Figure 12. Meanwhile, the line inventory record shows the existing quantities of NDM that are used in the workstations of a production line. An example of this record has been depicted in Figure 13.

8.0 DISCUSSION

The focus of the interview is to find out the good practices of other companies in controlling their inventory of NDM. However, the results show that most of the companies interviewed do not apply any particular inventory control system that specifies the desired inventory level, reorder period, reorder point and safety stock level of NDM that are kept in the store.

Several systems have been recommended in the literature. The systems describe general guidelines on how to manage the inventory of materials that can be modified to cater for NDM. These systems are defined by several key factors. However, to determine these factors, historical data like annual usage rate and the average lead-time of NDM is required.

In fact, it is a good practice in determining the type and quantity of stocks based on the actual usage because it is thought to be a realistic approach in the absence of an exact model. However, in the absence of a proper NDM management model developed and implemented in the company, there is no comprehensive and reliable previous record showing the usage of NDM. Thus, by introducing a computer database, the immediate issuance transaction can be recorded starting from then. Only after sufficient data is available, the type and quantity of stocked items can be worked out based on the issuance record.

9.0 CONCLUSION

The outcome of this study is a set of new procedures that can be applied to manage and control NDM in the company. The procedures cover the aspects of requisition, issuance, purchase, receipt, return, repair and scrap.

Additionally, a computer database system has been developed to incorporate the procedures into an effective management tool. It assists the execution of the

procedures by recording and storing all the transactions in the computer. It can also be used to generate the material status and investment reports, which would provide useful information to the company in managing and controlling NDM.

Overall Line Investment

Line No	*Total NDM Investment*
2.6	$155,702.50

Figure 18 NDM investment cost in line 2.6

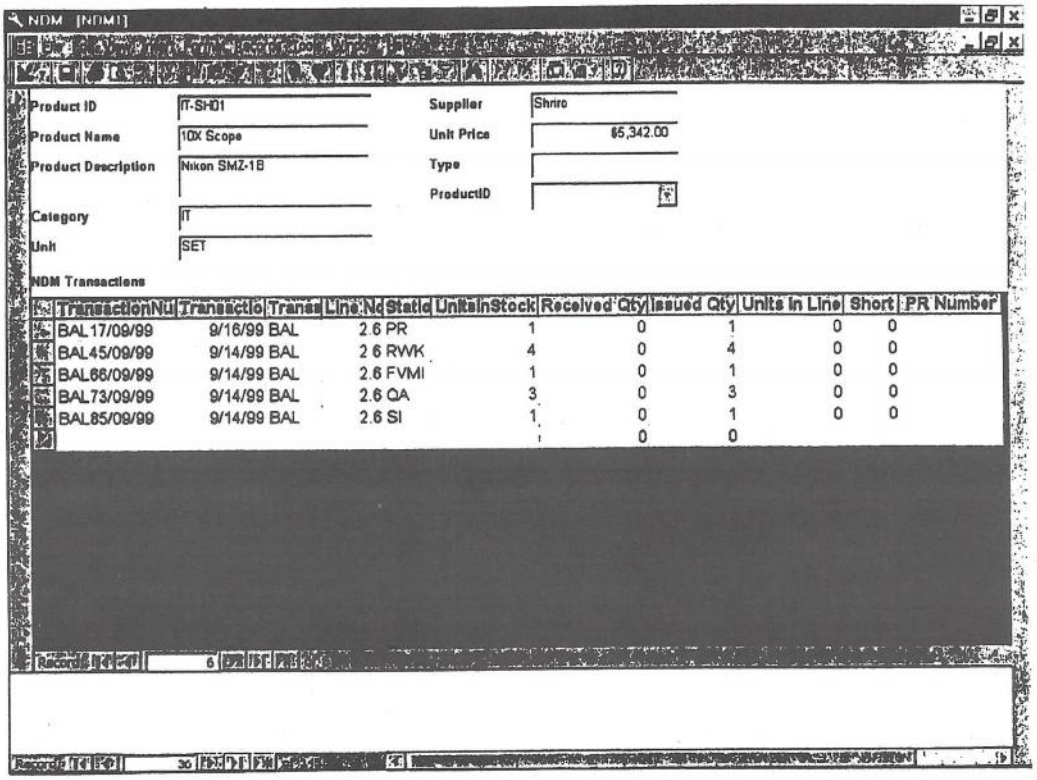


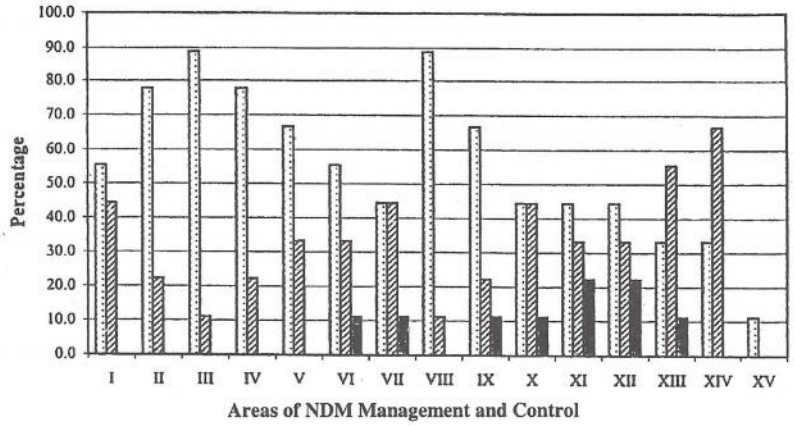
Figure 19 Example of NDM transaction resord

REFERENCES

1. Ammer, D.S., 1980, *"Materials Management and Purchasing"*, Richard D. Irwin Inc., Illinois.
2. Gopalakrishnan P. and Sundaresan, M., 1992, *"Material Management - An Integrated Approach"*, Prentice Hall of India, New Delhi.
3. Magad, E.L. and Amos J.M., 1995, *"Total Material Management"* Chapman & Hall, New York.
4. Tersine, R.J., 1976, *"Material Management and Inventory Systems"*, North-Holland, New York.
5. Thomas, A.B., 1980, *"Stock Control in Manufacturing Industries"*, Gower Press, England.
6. Fink, A., 1995, *"The Survey Kit – The Survey Handbook"*, SAGE Publication Inc., California.

APPENDIX A: Partial Summary of Results of Questionaire

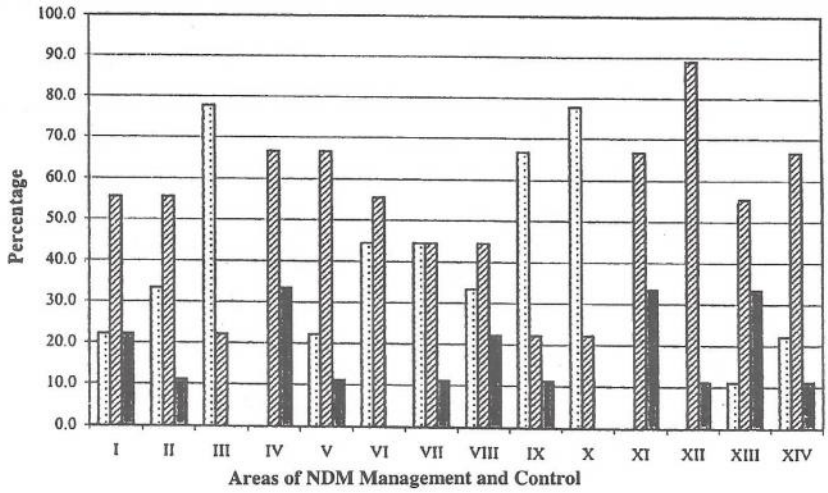
1. Respondents (company management and manufacturing engineers) have been asked to identify which areas of NDM management and control are important and which need urgent improvement.



KEY: Important and Urgent; Important and Not Urgent; Not Important.

DESCRIPTION OF AREAS:
I- purchase requisition procedure, II- receipt procedure, III- requisition procedure for replenishment, IV- requisition procedure for new line setup, V- issuance procedure, VI- expense report, VII- investment cost for each project, VIII- inventory record in store, IX- inventory record for each production line, X- return procedure, XI- repaire procedure, XII- scrap procedure, XIII- NDM coding, XIV- NDM reference list, XV- NDM store.

2. Respondants have been asked to indicate problems that they encounter frequently when dealing with NDM.



KEY: Frequently; Sometime; Seldom.
DESCRIPTION OF AREAS: As in 1 above.