

Automated Document Management for HVAC product: An Excel VBA Approach

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Abstract

This study develops an automated document management system for HVAC (Heating, Ventilation, and Air Conditioning) products using Excel VBA to solve problems with the current manual processes. The Manufacturing Engineering department handles over 5,000 documents for ten different product types. Each product needs five types of documents: Engineering Technical Standard (ETS), Working Standard (WS), Process Flow Chart (PFC), Failure Mode and Effects Analysis (FMEA), and Control Plan (QPCC). The current manual system causes many problems such as taking a long time to process documents, making mistakes when entering data, and having trouble finding documents when needed. The objectives of this research are to develop a document management system for the master list of HVAC products using Excel VBA and to reduce data processing time, minimize errors, and prevent data loss in the manufacturing engineering department. The research applied the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as a systematic framework for application development design. The new VBA-based system automatically handles data entry, tracks document revisions, creates hyperlinks, and provides search functions. This system effectively eliminates repetitive manual processes and reduces errors, while improving document accessibility and data accuracy. During the evaluation process, the system was tested in a real working environment, focusing on measuring document processing time and data accuracy. The results show significant improvements: processing time dropped by over 60%, data accuracy improved from 95% to 100%, and lost documents were eliminated. These results prove that Excel VBA is an effective and affordable solution for improving document management in companies.

Keywords: Excel VBA, ADDIE Model, Master List, Document Automation, Quality Control

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1. Introduction

In the automotive industry, the document storage system for HVAC products plays a crucial role in quality control and supporting production processes. Currently, the Manufacturing Engineering Department is responsible for managing documents related to more than 10 types of products. Each product is associated with five key types of documents, namely the Engineering Technical Standard (ETS), Working Standard (WS), Process Flow Chart (PFC), Failure Mode and Effects Analysis (FMEA), and Control Plan (QPCC).

However, the existing document storage system, which relies on Microsoft Excel, has several limitations, particularly in terms of complexity in recording and retrieving information. The process of creating and maintaining the Master List, which keeps a record of document revisions, is performed manually.

Normally, the process of registering a new document involves 19 steps and takes an average of 6 Minutes per document, while modifying an existing document involves 17 steps and takes an average of 2 Minutes per document. The processing time varies depending on the document type and the number of revisions required.

Manual data entry in the current system presents several risks, such as incorrect hyperlinking to the latest document versions, misplacement of revision details, or errors in recording the document's effective date.

These issues lead to delays in verification, particularly when retrieving historical documents that have been replaced or archived. Additionally, the Quality Department must manually duplicate and circulate documents for approval and signature. Once approved, documents are stored as Excel and PDF files in the Document Control Center, with older versions being deleted. As a result, when customer complaints arise regarding product issues, the Manufacturing Engineering Department faces challenges in accessing past document records efficiently.

To address these challenges, this research focuses on developing an automated document storage and retrieval system using Visual Basic for Applications (VBA) in Microsoft Excel. VBA enables automated data entry, minimizes redundant manual input, enhances document hyperlinking precision, and reduces human errors. The primary objectives of this research are:

- 1) to develop a document management system for the master list of HVAC products using Excel VBA
- 2) to reduce data processing time, minimize errors, and prevent data loss in the manufacturing engineering department.

The rest of this paper is organized as follows. Section 2 reviews the related literature on VBA for Excel and the ADDIE model. Section 3 explains the research methodology based on the ADDIE model

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(figure 1), detailing the phases of Analysis, Design, Development, and Implementation. Section 4 presents the results and discussion, including the Evaluation phase of the ADDIE process. Finally, Section 5 concludes the study, outlining its limitations and providing suggestions for future research.

2. Literature Review

2.1 VBA for Excel

Visual Basic for Applications (VBA) is a programming language integrated within Microsoft Excel that allows for task automation, user interface customization, and the development of interactive systems. Research across education, engineering, and organizational domains has shown that VBA plays an important role in improving productivity, accuracy, and user engagement.

In the educational context, Ulfa and Laily [1] demonstrated that incorporating VBA into vocational accounting practice significantly improved students' ability to complete worksheets and understand accounting workflows. Bernard and Senjayawati [2] developed an Excel VBA-based game to support junior high school students in learning algebra, resulting in improved comprehension and self-confidence. Likewise, Wijaya et al. [3] applied VBA alongside a six-question cognitive theory framework to teach fractions, enabling students to engage in meaningful learning experiences and

significantly improve their conceptual understanding.

In technical and scientific domains, VBA has proven valuable in simulating and optimizing complex processes. Golman and Yermukhambetova [4] created a VBA-based simulation module for energy optimization in spray drying processes, helping chemical engineering students analyze scenarios without needing commercial simulation software. In geoscience, Li et al. [5] introduced GeoBalance, a VBA-driven tool for performing mass balance calculations, matrix operations, and Monte Carlo simulations, making it an accessible solution for geochemical modeling.

From an organizational and operational standpoint, Chaudhry et al. [6] automated a demand management system using Excel VBA, which reduced report generation time by 84.42% and eliminated human error in the Civil Aviation Authority of Pakistan. Rahayu et al. [7] demonstrated that VBA-based learning games effectively improved elementary students' decision-making skills, supporting active learning through interactive design.

Specifically in logistics operations, Klinnak [8] developed a VBA tool to calculate the maximum placement of packages on pallets, helping to reduce calculation errors, communication issues, and document loss. Moreover, Khan et al. [9] automated the material delivery time analysis report in a footwear company using Excel VBA, which

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resulted in a 70.86% reduction in report preparation time, improved accuracy, and enhanced productivity. The study demonstrated the practical value of VBA in logistics reporting by transforming repetitive manual tasks into a single-click solution using macros and user forms. Together, these studies reinforce that Excel VBA is a highly adaptable and efficient tool that enhances both educational and operational processes through automation, visualization, and interactive user engagement.

2.2 ADDIE Model

The ADDIE model, which consists of five sequential phases including Analysis, Design, Development, Implementation, and Evaluation, has been widely adopted as a structured framework for developing functional and educational applications. It is recognized for supporting a systematic, step-by-step development process that aligns application features with user needs and learning objectives. In addition, its iterative nature enables continuous refinement based on user feedback and testing, which is essential for ensuring relevance, usability, and overall effectiveness.

Many researchers have applied the ADDIE model in a variety of ways to guide the development of applications that are both technically robust and user focused. For example, Mardianto et al. [10] and Zulkifli et al. [11] applied the model in the development of game-based learning tools

for Islamic education and early childhood learning, respectively. Their use of the model demonstrated how the initial phases, particularly the Analysis and Design stages, help define user profiles and structure relevant content. Meanwhile, the later phases ensure usability and engagement through testing, implementation, and iterative improvement. Likewise, Aydin et al. [12] and Samsudin et al. [13] employed the model in the development of mobile health and assistive applications, highlighting the value of detailed user analysis, multimedia integration, and structured evaluation. These studies emphasize the importance of formative feedback in refining application features to meet the needs of specific user groups, such as patients in recovery or individuals with special learning needs. Furthermore, Razali and Shahbodin [14] applied the ADDIE model to develop a project-based collaborative learning platform, demonstrating the model's ability to support structured content delivery, interactive design, and ongoing evaluation to enhance learning experiences.

In summary, the ADDIE model provides a comprehensive and adaptable framework for application development. It ensures that each phase of the process supports clear objectives, structured execution, and responsiveness to user needs. This makes it particularly suitable for developing interactive tools such as Excel VBA applications, where both usability and effectiveness are key to success.

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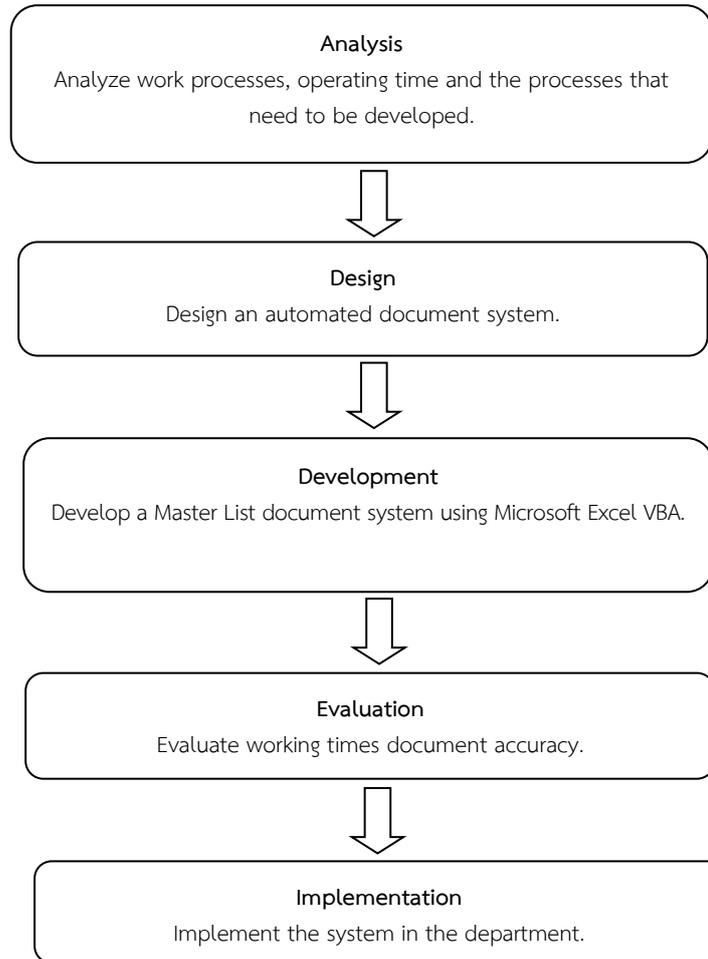


Figure 1. ADDIE Model

Table 1: Total number of new registration documents and edited documents

Products	Total number of new registration documents (copy)	Total number of edited documents (copy)	Total documents (copy)	Average time (minute/copy)
Blower	374	1,222	1,596	4.37
Evaporator	222	966	1,188	3.80
Heater	235	696	931	4.28
Heater Core	91	484	575	4.34
Injection Case	73	191	264	3.65
Slide Door	39	93	132	4.17
Rear Cooler	26	90	116	4.14
Ultra Tube Evaporator	39	69	108	3.98
Intake	15	77	92	4.02
Tube Sheet	30	47	77	4.16
Total	1,144	3,935	5,079	40.91

3. Research Methodology

The development of a data storage method for refrigeration products using VBA in Microsoft Excel, employing the ADDIE Model. The principles are as follows: Analysis, Design, Development, Implementation, and Evaluation. The development processes are as follows:

3.1 Analysis

Manufacturing Engineer Section stores documents for ten important products, namely: Evaporator, Heater Core, Ultra tube evaporator, Injection Case, Slide Door, Blower, Heater, Rear cooler, Intake and Tube sheet. Each product consists of five types of documents: Engineering Technical Standard (ETS), Working Standard (WS), Process Flow Chart (PFC), Failure Mode and Effects Analysis (FMEA), and Control Plan (QPCC). All the documents serve as detailed documentation for a single product.

The product documents newly created or revised by the Manufacturing Engineering Department are the initial versions, as they must be sent to the Quality Department and authorized personnel for approval. Once the authorized personnel approved, it is saved in both Excel and PDF formats in the Document Control Center, and the old version of the file is deleted. This document will be retrieved and used again if a customer files a complaint regarding a product defect.

Previously, the Manufacturing Engineering Department addressed document retrieval

issues by creating a Master List in Excel, allowing them to see the document revision details from initiation to approval. However, the process of creating a Master List for each product was very time-consuming due to the large number of documents and complexity of the steps involved. This led to errors in data entry and document searching caused by human error. The usual workflow involved manually copying data and creating hyperlinks for both Excel and PDF files, resulting in a complicated, time-consuming, and error-prone search process. Based on calculations, employees spend approximately 4 Minutes per document totaling around five thousand documents for the five main products. As shown in Table 1, this amounted to roughly 333 hours in total. This clearly shows that the company has spent a significant number of resources managing these documents manually.

Based on the data from table 1, we chose the products for Master List document system development using the Pareto principle. From the analysis, the total number of documents and the processing time were categorized by product type. It showed that the Blower product took the longest amount of time to process, accounting for 33 %, which falls into Class A of Pareto. Nevertheless, the researcher developed the document systems for Evaporator, Heater, Heater Core, and Injection Case, which falls into Class B. Altogether, these account for a cumulative percentage of 90 percent of the issues

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related to data storage in Master List, as shown in Figure 2.

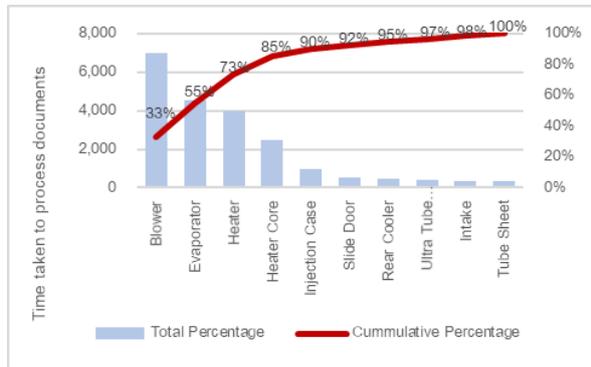


Figure 2. Pareto chart of the time required to process documents.

3.2 Design

Based on the document issues, we developed a document management system with Master List using Microsoft Excel VBA. The program automates the creation of the Master List, guiding users to input data as specified by the system. The design results show that this approach reduces redundant tasks, minimizes data entry errors, and prevents issues related to missing documents during searches.

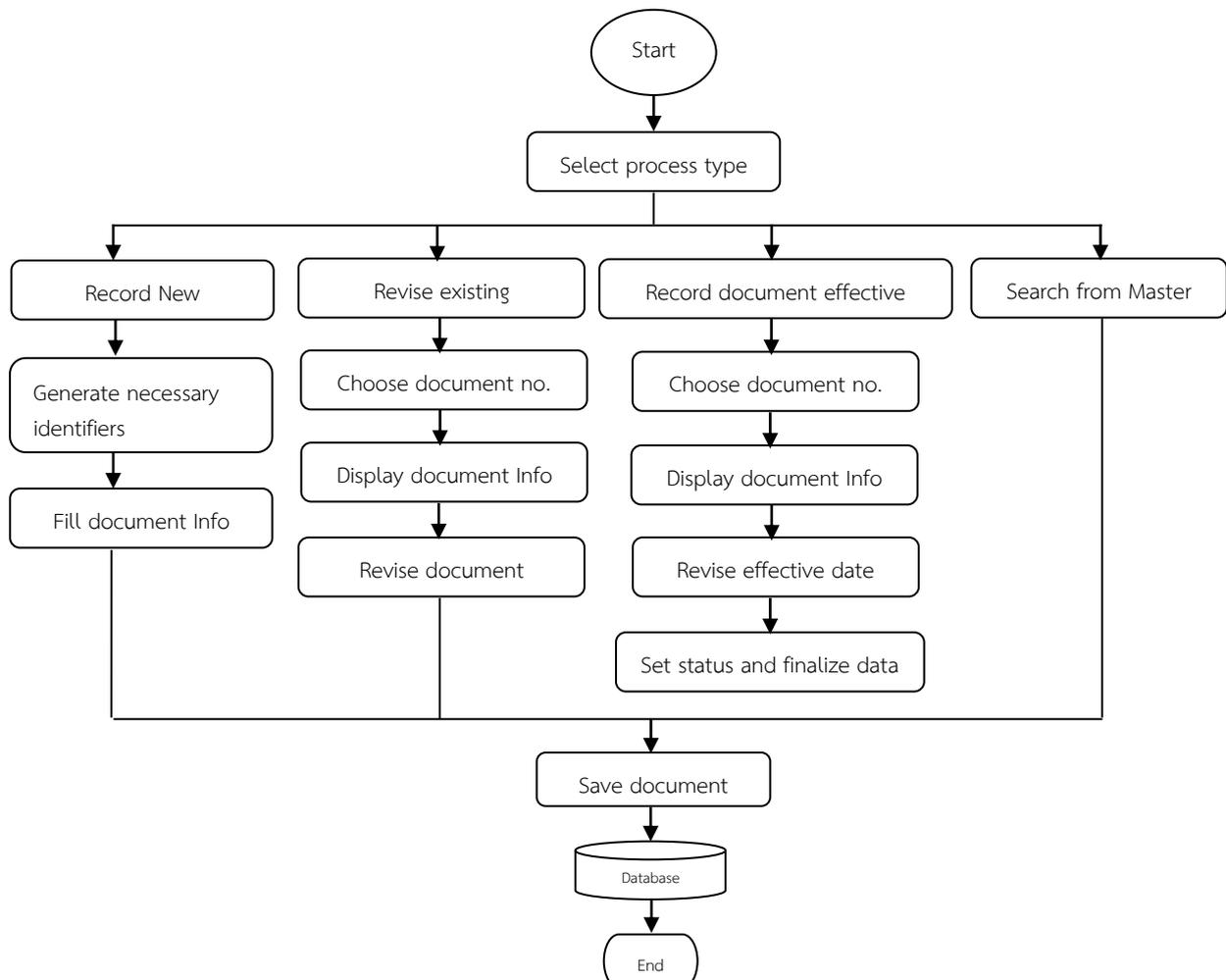


Figure 3. The Master List system workflow

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An example of the program’s operation: When a user opens the file, the program prompts the user to select the document type they want. If the user chooses to record a new document, the program automatically displays the document number and revision count. The user then fills in the required information, after which the program automatically adds the data to the database table and highlights the data. If the user chooses to record a document revision, the program asks the user to select the document number, then automatically displays the relevant data. After the user inputs the updated document details, the program again adds the data to the database table and highlights it automatically. The program is designed for user convenience and to minimize human error, the process is as shown in Figure 3.

3.3 Development

After designing the Master List document storage process using Microsoft Excel, as shown in Figure 3, we developed a main menu categorized into five document types. When the user launches the program, it will open a menu consisting of the five types of documents: ETS, WS, PFC, FMEA, and QPCC as shown in Figure 4.

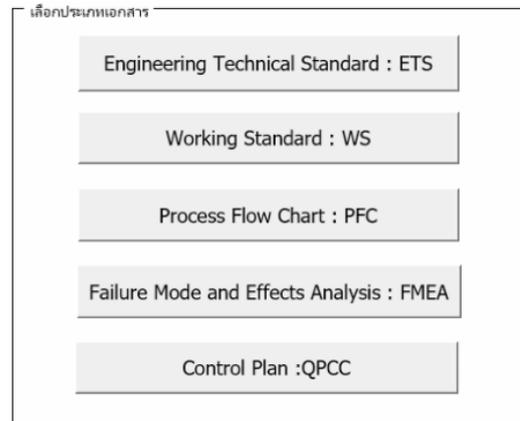


Figure 4. Main Menu in Master List documents system

After choosing the desired document, the menu will then display another menu consisting of four options: Record new document, Revise existing documents, Record document effective date, and Search from Master List. In case of Recording new document, the system will display a window for entering new document information, which consists of: First, Master List (No.), Second, Document No., Third, Model, Fourth, Revisions, Fifth, Document Name, Sixth, Equipment, and Lastly, Seventh, Revision Record. After inputting all data, it will be automatically saved into Master List, simultaneously displaying a screen to enter additional information.

In the case of document revising, the system will display a window for saving the revised document information, along with retrieving the previously saved data for modification, as shown in Figure 5.

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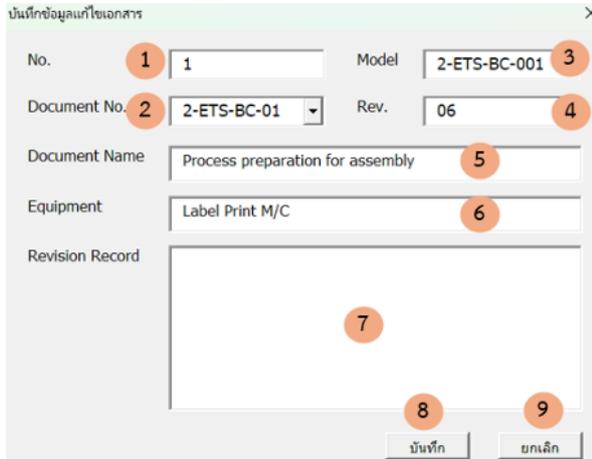


Figure 5. Revising document window

Once the data has been edited and saved. The system will automatically perform the following actions:

First, Delete the Excel file data that was previously hyperlinked from the earlier revision count. Second, Remove the remark data for the establishment. Third, Copy the previous document revision data (Rev.) including the Document Name and Equipment, and display the revision record results. Lastly, highlight incomplete data in yellow, as shown in Figure 6.

Document No.	Link Excel	Link PDF	Model	RI	Document Name	Equipment	Revision Record	Issue by	Effective Date	Register Status	Remark
78	2-ETS-BC-078	No Data		00	Process preparation for assembly	Piping sensor	New Release	C.Thanavut	27 Oct 20	OK	
		2-ETS-BC-078		01	Process preparation for assembly	Piping sensor	Change company name from Marelli to Marelli cabin comfort	C.Thanavut	15 Jan 21	OK	
				02	Process preparation for assembly	Piping sensor	Change company name MCCT to High Marelli	C.Thanavut	4 Jan 22	OK	
				03	Process preparation for assembly	Piping sensor	xxxxxxxxxxxx				

Figure 6. Results of revising document data

In the case of recording document effective date, the system will display a window for entering the document's effective date, which consists of two sections, as shown in Figure 7.

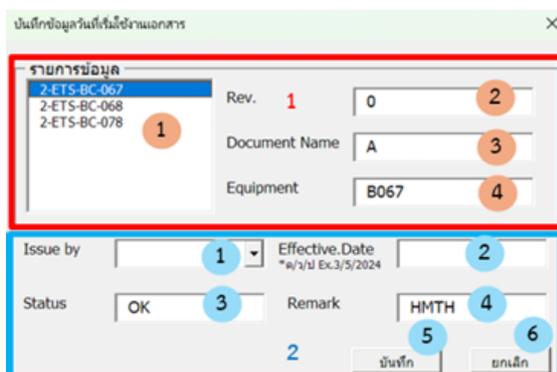


Figure 7. Record documents effective date

The data list section consists of four boxes. First, Document No., which indicates records with incomplete information. When a user selects a document number, the program will automatically fill up the subsequent fields (Revision Number (Rev.), Document Name, and Equipment) to reduce the risk of entering information for the wrong document. This automatic display function helps enhance data accuracy and streamlines the document entry process.

The document effective date entry section consists of six components. First, Issue by, where users can select a name from the list. Second, Effective Date, which must be entered in the MM/DD/YYYY format.

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Third, Status, which is automatically set to "OK". Fourth, Remark, which is also automatically displayed. Fifth and sixth are the Save and Cancel buttons, respectively.

After pressing the save button, the system will record the document's effective date and remove the yellow highlight, changing the fields color to blue: Issue by, Effective Date, Status, and Remark in Figure 8.

	Issue by	DC	Register	Remark
		Effective Date	Status	
Marelli	C.Thanakit	4 Jan 22	OK	
	Wachirssak	2 Mar 24	OK	H/M/T

Figure 8. Results of document effective date data recording

When a user selects the option to search from the Master List, the system will display a search window. The user can choose the desired Document No. to check. After selecting Document No., Upon clicking "OK," the program will display the corresponding document data based on the selected number, as shown in Figure 9.

Document No.	Link Excel	Link PDF	Model
	2-ETS-BC-004	2-ETS-BC-004	B02A
5 2-ETS-BC-005		No Data	B02A
	2-ETS-BC-005	2-ETS-BC-005	B02A

Figure 9. Results of searching data from Master List

3.4 Implementation

After developing the Master List document management system using Microsoft Excel VBA, we implemented the system within the production engineering department to evaluate its operational performance. The system was tested in a real working environment, where data were collected using a quantitative approach. The evaluation focused on two key aspects: the time required to complete document processing tasks and the accuracy of recorded information, to assess the overall efficiency of the system.

4. Results and Discussion (Evaluation)

In terms of program performance evaluation, the system was early tested in a real working environment by limited number of five engineers in the production department. The evaluation focused on operational performance, specifically document processing time and accuracy over a one-week period. No personal or behavioral data was collected during the process. This study was classified as internal system performance testing and aimed to assess improvements in two critical areas: the accuracy of recorded documents and the time required for document processing.

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Table 2: Comparison of the Document Entry Durations Before and After using the VBA System.

Document Type	Total Document	Manual operation		Using Excel VBA		Time Reduced (%)
		Time	Time	Time	Time	
		(Minutes)	(Minutes/Copy)	(Minutes)	(Minutes/Copy)	
Blower	1,596	6,978	4.37	2,732	1.71	60.85
Evaporator	1,188	4,503	3.80	1,801	1.52	60.00
Heater	931	3,982	4.28	1,553	1.67	61.00
Heater Core	575	2,495	4.34	974	1.69	60.96
Injection Case	264	964	3.65	378	1.43	60.79

4.1 Comparison of Document Entry Time in the Master List

To evaluate the efficiency of the system developed with VBA for managing production document data, this study examined the document entry process in the Master List before and after implementing the VBA system. The focus was on measuring the time required to record each type of document, as the previous manual process was inefficient and could easily lead to mistakes.

Table 2 presents a comparison of the time required to record data into the Master List system for five types of product documents, before and after implementing Excel VBA. The data were based on actual document entries in the system.

After applying the VBA-based system, the time needed for data entry decreased significantly across all document categories. For instance, Blower documents, the most numerous with 1,596 entries, saw their

average input time reduced from 4.37 Minutes to 1.71 Minutes per document, a 60.85% reduction. The Heater category showed the greatest improvement at 61.00%, while Injection Case, despite having the fewest number of entries, still achieved a 60.79% reduction.

The results show that the developed Excel VBA system significantly improved data entry efficiency by automating repetitive tasks. The system was programmed to automatically execute and verify document records, helping users handle many documents efficiently. This not only reduced workload but also enhanced the reliability and speed of the overall document management process. Which is consistent with the studies by Chaudhry et al. [6] and Kalwar et al. [15], stating that VBA facilitates automation in operations, resulting in reduced working time and improved human performance.

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4.2 Comparison of Data Accuracy and Lost Documents from the Master List

In terms of program performance evaluation, this study conducted quantitative data collection on the accuracy of document recording and the occurrence of lost documents before and after implementing the VBA-based system for recording data in the Master List, as shown in Table 3.

Based on the data in Table 3, it was found that prior to the improvement of the system, the average accuracy of document recording was approximately 95%, while the average rate of lost documents was around

2%. Notably, the Blower document type had the highest rate of lost documents. After the implementation of the Excel VBA, all document types achieved 100% accuracy, and the rate of Lost documents dropped to 0%. This clearly shows the effectiveness of using Excel VBA in significantly reducing errors and enhancing the efficiency of document storage and retrieval. This result is consistent with the studies by Khan et al. [9] and Kalwar et al. [16], which found that using Excel VBA can improve the accuracy of document storage and recording to 100%.

Table 3: Comparison of Errors in Document Recording and Retrieval from the Master List

Document Type	Total Document	Before Improvement		After Improvement	
		Accuracy (%)	Lost Document (%)	Accuracy (%)	Lost Document (%)
Blower	1,596	95.24	2.85	100	0
Evaporator	1,188	94.36	1.53	100	0
Heater	931	98.28	1.78	100	0
Heater Core	575	94.26	2.04	100	0
Injection Case	264	94.70	0.00	100	0

5. Conclusion and Future work

This research aimed to develop an efficient document management system for the Master List of refrigeration products by using Excel VBA, focusing on improving document processing times, reducing errors, and eliminating lost documents. Quantitative

evaluation results clearly demonstrate the effectiveness of the VBA-based system. The results show a significant reduction in the time required to enter each document, from approximately 4 Minutes to just 1.6 Minutes per document. This represents a reduction of

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more than 60 percent compared to the previous manual method.

The Cost–Benefit Analysis conducted to assess the economic feasibility from an industrial engineering perspective based on the reduction in document processing time from 4 Minutes to 1.6 Minutes per document demonstrates a significant improvement in operational efficiency. This reflects a time saving of 2.4 Minutes per document. Assuming a labor cost of 1 baht per minute, this time reduction translates into a labor cost saving of approximately 2.4 baht per document. With an estimated volume of 10,000 documents processed annually, the total cost savings would amount to 24,000 baht per year.

Furthermore, the implementation of the VBA system significantly improved the accuracy of data recording, increasing from an average of about 95 percent to 100 percent. It eliminated the problem of lost documents, which occurred at around 2 percent when using manual recording. These findings highlight the strong potential and practical benefits of using Excel VBA as a reliable tool for improving document management. It helps achieve better efficiency, higher accuracy, and easier access to information. These results demonstrate that even simple tools like Excel VBA can bring industry-grade improvements in document control.

This research is only the first phase in the design and validation of an automated

program for managing Master List documents. It is currently limited to trials conducted by engineers within the relevant department. However, the developed program will be implemented in other departments to increase the number of users and the duration of actual usage. Further development may be required, incorporating feedback from a more diverse group of users and evaluating user satisfaction. In subsequent phases of the research, it may be necessary to obtain research ethics approval to collect evaluation data. In addition, statistical methods may be employed to support the analysis in order to enhance academic credibility.

Future research may also consider connecting the VBA-based system with cloud storage or database platforms such as Microsoft Access or SharePoint. This could enhance data accessibility, support real-time collaboration, and improve version control, making the system more practical and scalable for broader organizational use.

Using Excel VBA for document management within an organization can be a cost-effective solution, as it requires low investment and allows for customized functions tailored to specific needs without the complexity of large-scale systems. It is particularly suitable for organizations already relying on Excel as a primary tool, enabling quick and easy implementation. However, Excel VBA may not be ideal for handling large volumes of data or for organizations that require high system stability and

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scalability in the long term. In contrast, Document Management Systems (DMS) are specifically designed for structured document control, offering features such as version control, access permissions, and audit trails, which enhance security and organization. ERP systems, on the other hand, are more suitable for large organizations aiming to integrate various business processes into a unified platform. While ERP solutions often involve high implementation and maintenance costs, they provide comprehensive and systematic management capabilities. Cloud-based solutions have become increasingly popular among modern organizations due to their flexibility, allowing access from any device, real-time collaboration, and scalable usage. However, concerns regarding data privacy and reliance on continuous internet connectivity remain potential limitations.

6. Declaration of Generative AI and AI-assisted Technologies

The authors were responsible for all main research processes, including literature review, research methodology design, system development, data collection, and analysis of results. Artificial intelligence (AI) tools were used only to assist with checking and improving the English language of the manuscript. After receiving suggestions from the AI, the authors thoroughly reviewed and revised all content to ensure accuracy, clarity, and consistency with the research objectives.

The authors take full responsibility for the content of this publication.

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