CHAPTER 6

IMPLEMENTATION AND EVALUATION

6. Implementation and Evaluation

The proposed quality assurance system has been implemented with a project named RCA2 project. This project was initiated in July 98. The implementation was taken from the beginning till the project's end in December of the same year. The detail of the implementation is discussed on the following section and the evaluation of the proposed quality assurance system will be discussed in the section 6.2.

6.1 Implementation of the Proposed Quality Assurance System

Before starting implementation of the proposed system in the RCA2 project, the project team was explained about the new and some added procedures in the project execution. The document used in the project was also explained to the project team as well. This was to ensure that all members in the project team understood the proposed quality assurance system.

In addition, the customer was also explained about the new DCS project execution and the document that would be used in the project before the project started. This was because there would be some document of the proposed quality assurance system that might affect to the customer's usual work procedure and habit. For example, the customer may like to continually improve, adjust, and change the control process requirement although the functional specification has already been approved.

6.1.1 RCA2 Project

This RCA2 project was for the same customer of the RCA project which was discussed previously in the chapter 4.2.1. The project was initiated because of the increasing in demand of the chlorine gas in the Eastern Industrial Seaboard area. The project started in July 1998 and the delivery date was in December 1998.

Since this was a new project and the plant's location was close to the existing one, the customer connected the new distributed control system to the existing DCS. The production capacity of this project is quite similar to the previous one but the control concept is rather different due to the machines and equipment used in the process are different. Note that the control requirement of this project was received directly from the end user.

6.1.2 Results of the Implementation

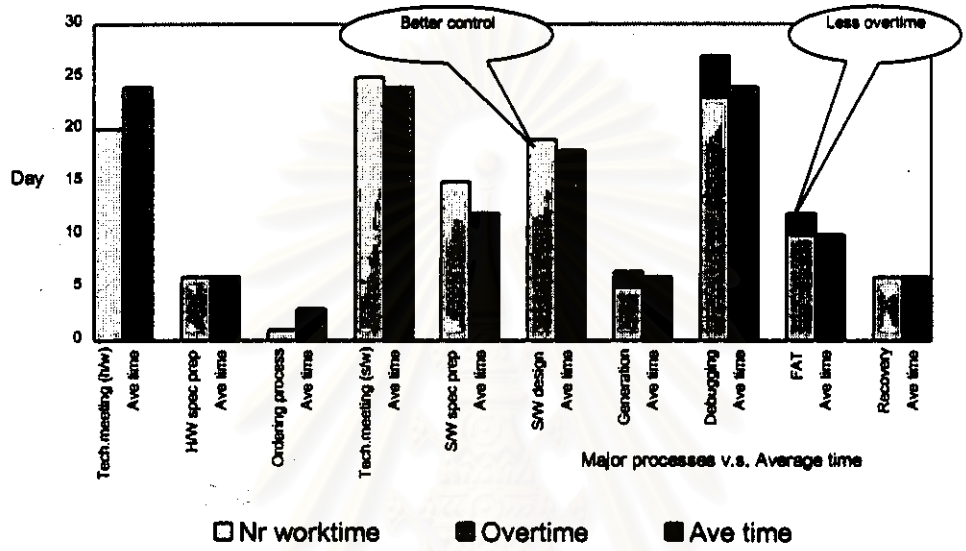

Figure 6.1 Time Used in Major Processes of RCA2 Project

Source: Data of the ABC Company

A. Technical Aspect

The basic design review checklist (D3) has guided the project team to review the general criteria of the system design, check and confirm the requirements before proceeding the subsequent phases of the project execution. This has prevented the problems from occurring because all necessary items of the system design, such as the system capacity and CPU loading, have been checked at the earlier stages of the project execution.

The monitoring of the project can be done closely with the use of the walk-through form (D4). With this form D4, the project manager can easily monitor the progress of the project in term of tasks completed and tasks which are slipping. As a result, the project progress of this RCA2 project was under control and the jobs were completed at the target schedule.

There were less design changes in the RCA2 project, comparing to the design changes occurred in the past projects. This was because of the use of the change order form (D15) in the project. Whenever there was any request for changes after the functional specification has been approved, the discussion about the impact of both the project schedule and project cost was discussed. This greatly reduced the customer's demands for changes. In addition, this project had an additional income due to the design changes as shown on the following figure. The deviation costs due to design changes of this project was 250,000 Baht and there was no unexpected costs.

Number of reworks in term of document preparation and the software development in this project were less because there are several procedures added to the project executions to prevent such problems. These include the standard software specification, the design planning, design review and verification, design validation, and an internal FAT.

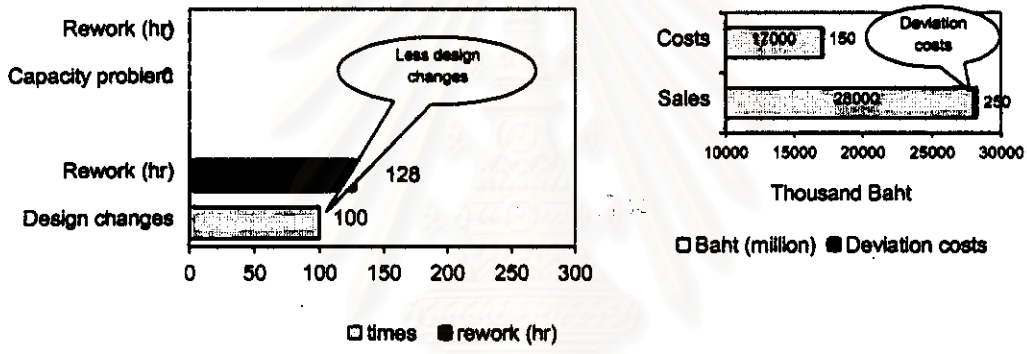

Figure 6.2 Technical and Financial Aspects of RCA2 Project

Source: Data of the ABC Company

B. Financial Aspect

The overtime spent in this project was less. This resulted from the use of the walkthrough form and the design planning sheets before starting the design tasks including the design of the hardware specification, software specification, and application software.

Since the number of reworks was less, the cost of reworking in this project, in term of both document preparation and software redesign, due to the changes in specification or design errors was few. As a result, the company could make profit from this project as was expected.

C. Customer Aspect

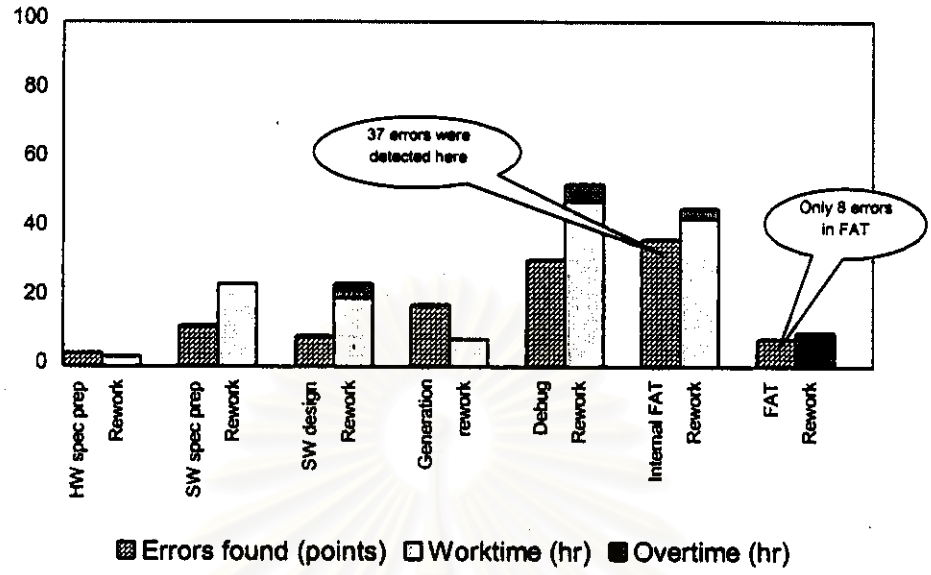

Figure 6.3 Errors Detected and Rework of RCA2 Project

Source: Data of the ABC Company

The project team found some deviations between the project contract (ABC scope of work) and the tender during the preliminary study of the internal KOM document. These discrepancies were immediately discussed with the customer during the customer KOM. Therefore, this has made the both parties understanding the scope of work clearly at the beginning of the project. This also prevented the customer misunderstanding about the ABC works that might lead to the customer dissatisfaction.

There still were some software errors but very less (8 errors found in the FAT period). These errors have been solved completely before the end of the factory acceptance test (FAT). In addition, the project team could keep the project schedule and was able to deliver the system at the agreed date. The system was delivered to site completely and in good condition because of the use of the pre-delivery review checklist (D22) and the final save procedure (D23). These led to the customer satisfaction at the project's end.

6.2 Evaluation of the Proposed Quality Assurance System

6.2.1 With the Failure Mode and Effect Analysis

After the RCA2 project has finished, there was a FMEA meeting to analyse the results of implementation. The Severity, Occurrence, and Detection of each process, which has its RPN greater than 100, is reevaluated by using the team judgement (see appendix II).

The RPN before and after implementation is compared and shown on the following table. From the table, the control documents (D1 to D28) have improved the DCS project execution as we could see from the RPN2 (after implementation) comparing with the RPN1 (before implementation). The percentage of change of RPN comparing between before and after implementation ranges from 33% to 94%. The occurrence (the probability that potential causes of the failures will occur) has been reduced because of the use of review checklists. The review checklists could remind the project team to do the necessary and important tasks in the project. In addition, the control documents have also increased the ability of the proposed system to detect potential causes of failures or detect the subsequent failure modes as we could see from the reduction of the detection (D).

Process	Potential Failure Mode	RPN1	RPN2	%Change
Job Request from Sales	Insufficient information receiving from sales	140	70	50
Internal KOM	Deviation bet. ITB and contract is not discussed	720	96	87
Internal KOM	Verbal commitments are not fully discussed	150	90	40
Review Data/Document after KOM	Failure to check the cust. data/doc completely	350	45	87
Review Data/Document after KOM	Not revise the project execution plan	300	90	70
Hardware spec design	Failure to finish the h/w spec design on time	210	36	83
Prepare document for h/w ordering	Send wrong format document to order handling	120	27	78
Tech. meeting (S/W Requirement)	Misunderstanding the cust. control concept	400	96	76
Software spec design	No relationship of switch used between pages	480	72	85
Software spec design	Command used in flowchart is machine code	560	84	85
Software spec design	Abbreviation used have no explanation	480	72	85
Software spec design	Inconsistency bet. s/w spec of each project	400	60	85
Software design	Poor software structure	420	210	50
Software design	Using wrong buffer for sending data	320	64	80
Software design	Not fulfil the customer's requirements	400	160	60
Software design	Customer changes the approved spec	400	96	76
Monitoring of the project	Poor monitoring	448	84	81
DCS software debugging	Not enough time to debug all software	392	63	84
Factory Acceptance Test	Failure to conduct the test to finish on time	108	72	33
Factory Acceptance Test	Incomplete software	336	32	90
Acceptance of H/W and S/W	Customer do not accept the h/w and s/w	560	32	94
Prepare DCS for delivery	Some h/w items are forgotten to deliver to site	120	20	83
Prepare DCS for delivery	Do not complete the FAT punch items	210	24	89

Table 6.1 Comparison of the RPN before and after implementation

However, there are two processes that its RPN2 still exceeds the threshold value (100). These include the poor software structure and misunderstanding the control concept in the software design process. To improve the first process, that is to develop the software with good structure, it requires not only good documents to control the project execution, but also more DCS project experiences and some guidelines from senior engineers.

To reduce failure of the concept's misunderstanding which leads to the wrong software design, it is necessary to have a lot of discussions and use two-way communication with the customer during the meeting. That is, to re-explain the concept that customer just explained in our understanding back to the customer and check whether it is correct or not. The understanding of the concept is very important in order to develop the right software that customer needs.

There are some comments from the FMEA meeting and they are as follows:

1. Since members in each DCS project are different, so the interest in quality of the DCS project execution of each individual might be different. Therefore, it is necessary to have auditing standards and procedures in the process in order to check and control quality for each DCS project.

2. During the document preparation for the DCS hardware ordering, the project team has improved the process by finishing the ordering processing within one day. However, there still has a problem occurring in the RCA2 project. That is, one equipment that we have ordered to our local supplier was not delivered to the customer's factory at the agreed date. The cause of problem was that a staff of the order-handling department has already prepared the purchase order document but forgotten to fax it to the supplier. The FMEA team, therefore, has revised our ordering processing for the improvement of this process. That is, the project team has to receive two documents after finishing the ordering processing. These include the complete purchase order document for reference, and cover of purchase order with acknowledgement from supplier.

6.2.2 Improvements of the DCS Project Execution after Implementation

There are several improvements of the DCS project execution when we have applied the proposed quality assurance system to the DCS project. However, there are also some issues that we have to be aware of. Here below are the discussions of the newly proposed system.

6.2.2.1 Understand the Scope of Work and Customer Requirements Clearly

With the proposed system, the project team is required to study the document both the ABC scope of work and the tender or the customer requirements at the beginning of project. If any deviations or discrepancies between these documents are found, they are immediately discussed with the customer in the meeting. This can prevent problems of the scope of work in the project execution.

6.2.2.2 Project Monitoring with the Walkthrough Form: Pros and Cons

The proposed quality assurance system has helped the project manager to easily monitor the projects in term of task completed, slipping tasks, and the amount of resources expended at a certain period in a project as compared with the amount of resources planned. Through the use of the walkthrough form and the planning before each design task, the planning is carried out at a task level and in detail, not too general like the procedures of the project execution before improvement.

However, during the walkthrough meeting, it is important to explain clearly to the engineers in the team about the purpose of meeting. Otherwise, the engineers may have a negative picture with the walkthrough meeting and the project manager himself. Too much concentration on the project progress without any relaxation or technical supports to the team may cause the engineers feel worried and nervous. This may finally affect to the work quality and the project progress.

During the walkthrough meeting, it is very important that the recorder of walkthrough form (project manager) has to check whether 'the items to be done and when to finish it for each engineer' is realistic or possible or not. Since the engineers may not think about their work carefully, and may give the date to finish the task which is impossible. The unrealistic project schedule has no meaning, and may cause tension to the team during the walkthrough meeting. If unrealistic schedules have been recorded to the walkthrough form many times and engineers could not finish as said in the walkthrough form, engineers may finally not take the walkthrough meeting seriously and may not try to finish their work within the agreed date as stated in the walkthrough form.

6.2.2.3 Design Planning: Understand Work to be done and Schedule to finish Clearly

Prior to start each design task, the project team has to plan the design task in detail. The responsibility of each task is also identified. With this method, everyone in the team can see the actual quantity of work in each design task with the required finish date clearly. This helps the team to be aware of the project schedule and encourages the project team to work effectively.

6.2.2.4 Validation of Designs: Detect Errors at the Earlier Phases

With the new system, there is a quality control that provides evidence that a design meets the customer requirements at the end of each design task (hardware specification design, software functional specification design, and application software design). It does not simply ask the project manager to sign off the design but to check the specification or application software carefully. As a result, the errors are detected at the earlier phases of the project execution and reworks due to the design error decrease.

6.2.2.5 Unit Test Records: Ensure that the Application Software has been tested

The good point of the proposed quality assurance system is to ask every engineer in the project team to provide the evidence that his/her application software has been tested individually before stepping to the software integration. The software integration means to combine the application software made by each engineer together as the complete software system for delivering to the customer.

It is important to understand that discovering errors in a module when it is embedded in a whole system is many times more difficult than discovering errors in a module when it is tested by itself (Ince, 1994: 36). The proposed quality assurance system has ensured that errors found after the software combination would be less because the software of each individual has been tested already.

In addition, the engineers have to keep the internal inspection test results as well as the walkthrough forms in various phases in the document called Internal Inspection Records (D20). The D20 will be used for further reference, for example, it will be used during the software maintenance or modification task.

6.2.2.6 Configuration Management Practices: the Process of Change is managed

Configuration management is the process of documenting, appraising and implementing changes to a system (Ince, 1994: 37). When an error is discovered after the software functional specification has been already approved and it necessitates changes to the software functional specification and the software design, the proposed quality assurance system has introduced two documents into the project execution. The documents include D15 (Change Order Form) and D18 (Punch List Form).

- Change Order Form (D15)

If there are changes occurring in the project due to the customer requests, a decision to carry out the change is made by the project manager, sales manager, and the customer. The description of change, project schedule impact, and the project cost impact are discussed and recorded into the document D15. If the customer agrees for such impacts and approves the change order, the change is notified to the engineers in the project team for the document and software correction.

This form and procedure have helped the project manager to control the project schedule and cost effectively. From the RCA2 project, the project manager used this form to negotiate with the customer for the requested software changes that might heavily affect to the project schedule. As a result, the customer has approved the change order form only at the necessary changes. For this project, the ABC Company could charge the customer the deviation or impact cost at the project end, which was 250,000 Baht.

- Punch List Form (D18)

During the debugging phase, internal factory acceptance test, and factory acceptance test with the customer, software errors are found and recorded into the document D18. The engineers, who are responsible for the part of software that errors occur, correct the errors and record into the D18 the way to solve these errors with the date of completion. These errors are checked and validated by the project manager and acknowledged by the customer (the customer uses this form only at FAT period).

This form, when was applied to the RCA2 project, has helped the project team to solve the problems in a systematic manner. All troubles or errors were recorded at the same place in the punch list form. The project manager could check and validate whether all troubles have already been solved or not. In addition, the engineers were also asked to record the way to solve the problems, therefore the engineers in the engineering department could read this form, enhance their engineering knowledge, and would not repeat these errors again in the future. This is another way to prevent software errors in the project execution.

6.2.2.7 The Storage of Test Data: Easy for Searching the Past Software Data

The proposed system has asked the project team to store the walkthrough and the internal inspection test results in the internal inspection records (D20). This ensures that if the software modification is needed or retesting occurring, then little extra effort is expended in searching the historical software data and in redeveloping the software and the old test data.

6.2.2.8 Rationale for Decision-Making: Deeply Thinking during Software Design Task is developed

In the software design planning sheet (D13) of the proposed system, it asks the team members carrying out the software design activities to provide a rationale (set of reasons) for making the decision in the way that it was made. For example, the ideas of software structure and details are generated and discussed in the project team during the software design planning. The best structure supported with good reasons will be selected to develop the detail design. This procedure has encouraged the engineers to think more deeply about their design tasks. It also ensures that the functional part of the software functional specification is structured in such a way that all functions, which are connected with each other, are adjacent.

6.2.2.9 Improvements in the Project Activities

There are several improvements in the project activities. These include the time reduction during the ordering procedure, proper way of the media handling, and time reduction in the document searching with the use of document and data control system.

- Time Reduction During the Ordering Procedure

Prior to implement the proposed quality assurance system in the project, the normal time required for the ordering handling processing between the order handling and the engineering department is five working days. With the use of proposed method, the time required is reduced to just one day.

- Proper Way of the Media Handling Procedure

The proposed system has asked the engineers to back up the application software on each day (D17), so there was no mistake due to the media handling in the RCA2 project. The purpose of this document is to ensure that work done on a particular day is saved. If this work

is lost for some unforeseen reasons, the previous day's work is still available as a backup. If there is no quality system to control the media handling procedure, it takes long time to generating the loss of application software.

- Time Reduction in the Document Searching

The document and data control system which was applied in the RCA2 project has greatly reduced the document searching time for engineers in the project team. This is because there are several quality assurance activities to be done for the document and data control in the project execution. For example, the document with new revision is put the receipt date and kept separately from the previous revision. The new revision is kept at the customer document file which is used frequently for engineering work whereas the previous one is marked "OBSOLETE" and stored in the obsolete document file. This activity helps engineers in searching the required document with lesser time.

6.2.2.10 Engineering Database Pool Software: Reuse Software and Enhance Engineering Knowledge

The EDP software has helped engineers to enhance their engineering knowledge and to reuse the software that has already been developed. Therefore, in long term, the lead-time of the DCS software design should reduce because the number of developed software applications increase and they are stored in the engineering database pool for future reuse. In addition, engineers can also enhance their engineering knowledge by reading the knowledge stored in the EDP.