CHAPTER 4
DISCUSSION OF THE PROBLEMS

4.1 Current Organization

There are four main departments in the company organized to manage all project-related activities: Engineering, Sales and Marketing, Accounting and Finance, and Administration and Purchasing.

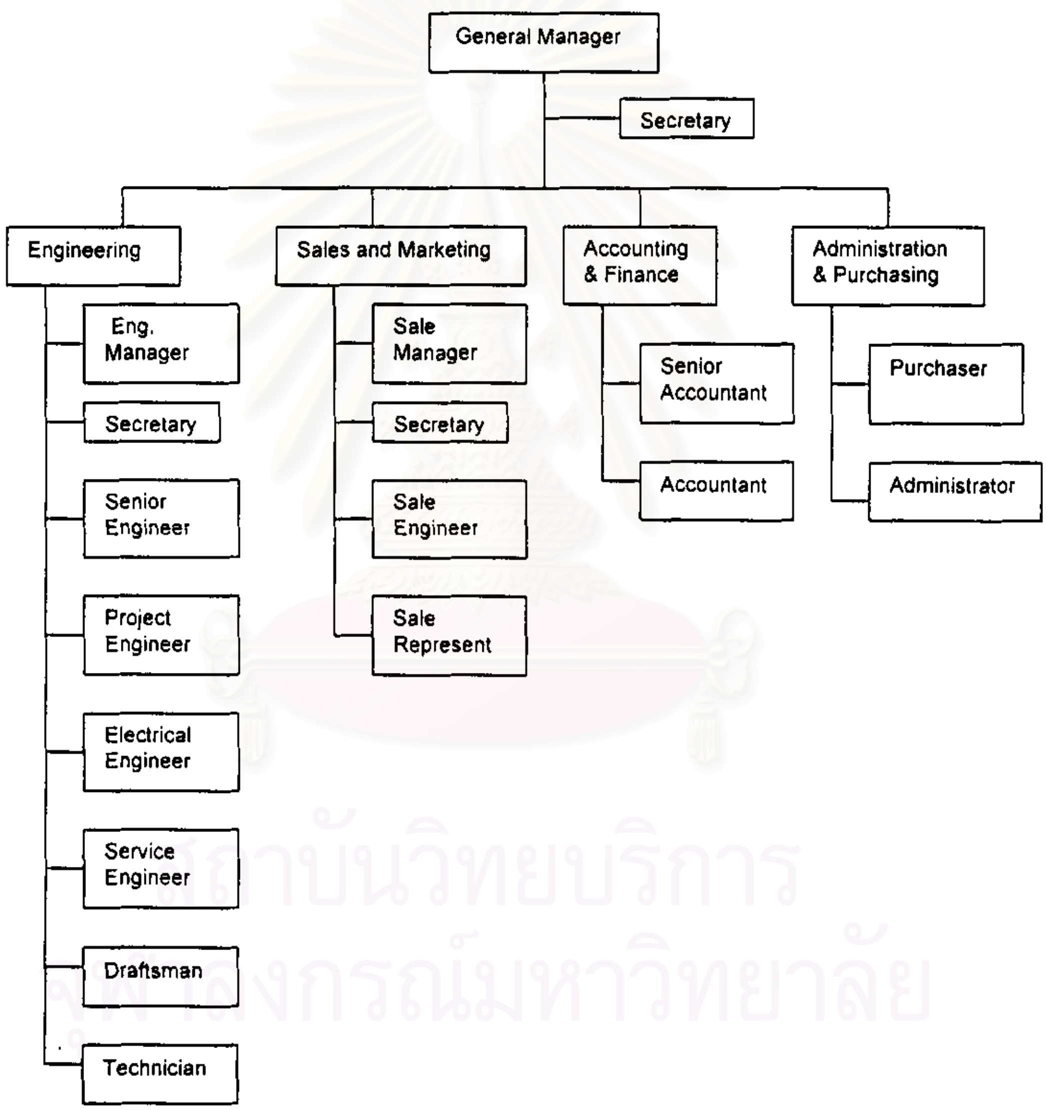

Figure 4.1 Organization Chart

However, as the Engineering department has main responsibility for project-related activities, it classifies the project team organization to two stages base on the characteristic of its operation. They include Project Organization Structure for Design Stage and Project Organization Structure for Installation stage. The former is basically used during the proposal preparation whereas the latter is used after the firm has got the project.

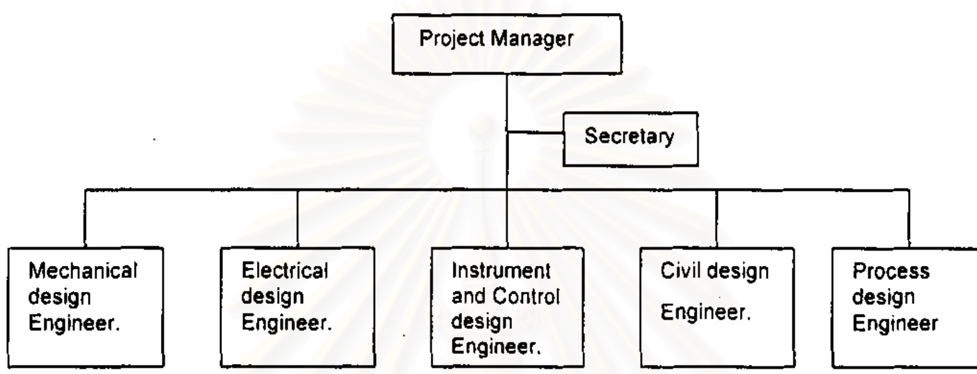

Figure 4.2 Project Team Organization for design stage

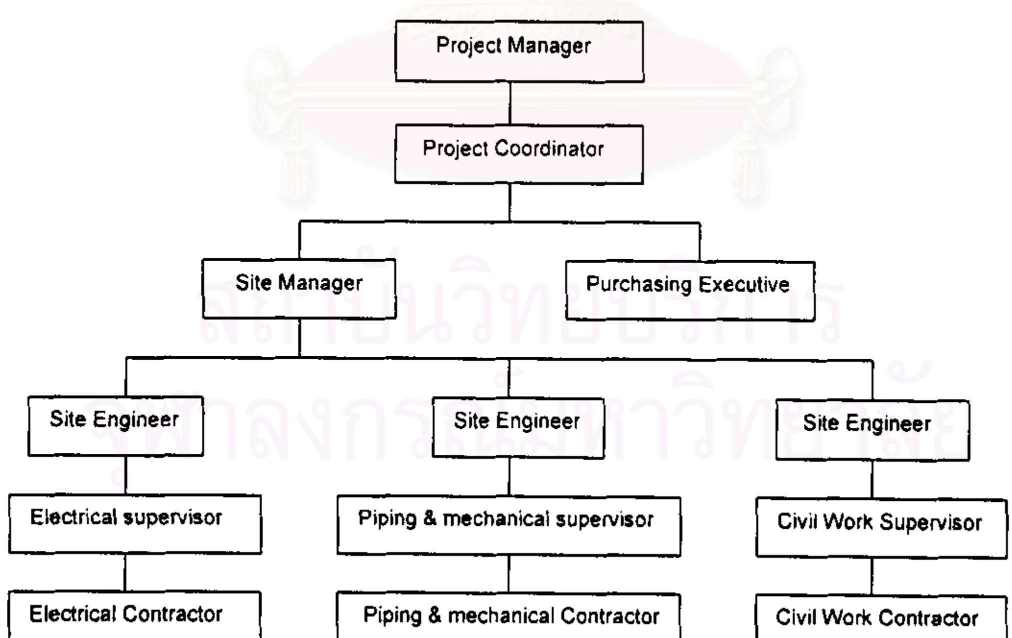

Figure 4.3 Project Team Organization for installation stage.

4.2 The present project execution

The procedure of current project management is separated into three main stages base on its function: the system and equipment design stage, equipment procurement stage, and installation stage. The descriptions below are the procedure for individual stage.

4.2.1 Design procedure

The basic design stage for the common water treatment project is separated to two phases. The first phase is to design for pre-awarded project or design for bidding and the second phase is to design for awarded project. The difference for those two phases is the intention of design. For the pre-awarded project the objective is to design the system that can produce the water quality in the capacity conforming to customer requirement. Thus, in the proposal there should describe what the equipment is used, how much its flow rate, what material of individual equipment, and what the instrument is used to monitoring the water quality such as flow indicator and conductivity meter. The purpose to design for awarded project is to clarify in how individual equipment can be made, what the component and accessories are required, and how individual equipment is controlled. Therefore, this design stage covers the detailed design for equipment assembly and fabrication (especially for domestically fabricated equipment), piping route, electrical control panel diagram and wiring route, and what the specification of other accessories such as pressure gauge and isolated valve.

4.2.1.1 Design procedure for pre-awarded project

There are six steps for the design procedure of pre-awarded project. Detail of each step is described as following:

Step 1.1 : Receive Project Requisition

The design procedure for pre-awarded project starts from design engineer receives Service requisition inquiry basically assigned by Engineering Manager. The requirement for the new project is normally come into the company via two ways. The former is by sale engineer approach directly to customer and get information and the latter is by opening bid arranged by owner itself or consultant firms. The service requisition enquiry form recorded the customer requirement in term of water treatment process and the capacity of required system. The attached information is usually raw water quality only.

Step 1.2 : Study Information

Then, design engineer studies the customer requirement (i.e. system capacity and treated water quality) recorded in the service requisition enquiry and general information (i.e. source of water and raw water quality) in order to design the conception of the system and select equipment specification.

Step 1.3 : Design concept

Conceptual design is specified in form of designed process flow sheet. In that sheet, there is proposed equipment or system that are used for water treatment step by step. This means that water quality is improved continuously until the final equipment or system, in which the outlet water quality meets the customer requirement at the required capacity as well. However, the customer requirement and supplied information from customer are different, so the kind of equipment or specific material is different project by project.

Step 1.4 : Design basic specification

After the conceptual process flow sheet has completed, individual equipment or process is designed basic specification such as dimension of tank, type and flow rate of pump, material of critical component, and the number of instrument required. For the design of equipment system, some system can be designed by the use of computerized program; for example, the ion exchange resins system and the membrane system.

Step 1.5 : Prepare design document and drawing

The next proceed is to prepare design specification document for estimation of each equipment cost and project management cost. It is noted that design document is usually made in forms of proposal.

Step 1.6 : Release design document for cost estimation

While the design document is prepared in form of proposal, a copy of detailed design system is released to discipline engineer to estimate the cost of equipment and also cost of project management. Total project cost will be sent to Engineering Manager to review and to quote the project price to customer.

Finally, the completed proposal and quotation are submitted to customer, together with the description of working scope, whole project lead time, and condition of sales. During customer evaluation, sale engineer has responsibility to following up the status of that project and submit additional information, if required. Also design engineer has to clarify the ambiguous data and revise the designed system due to the request of customer.

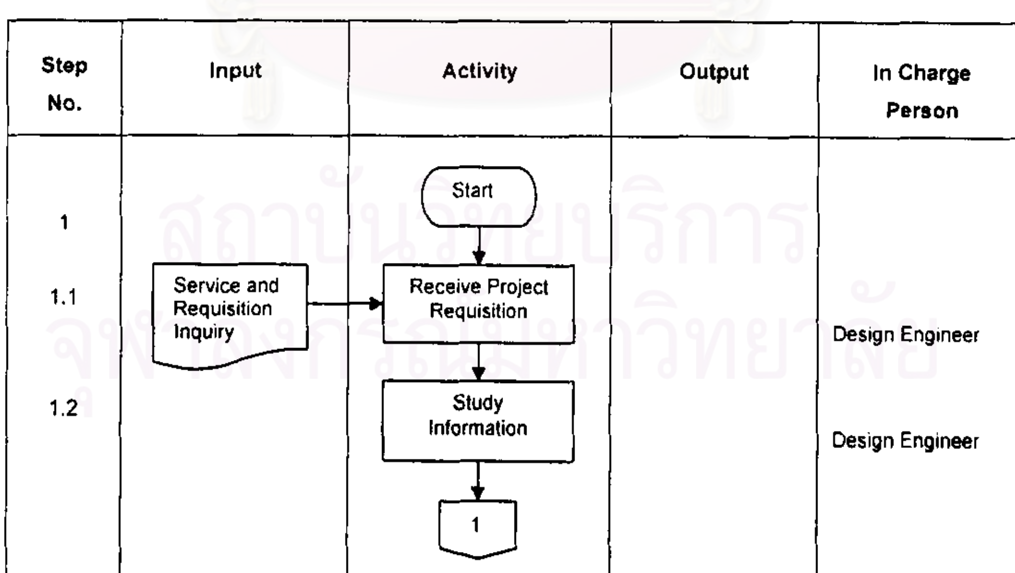

Figure 4.4 Procedure of design stage for pre-awarded project

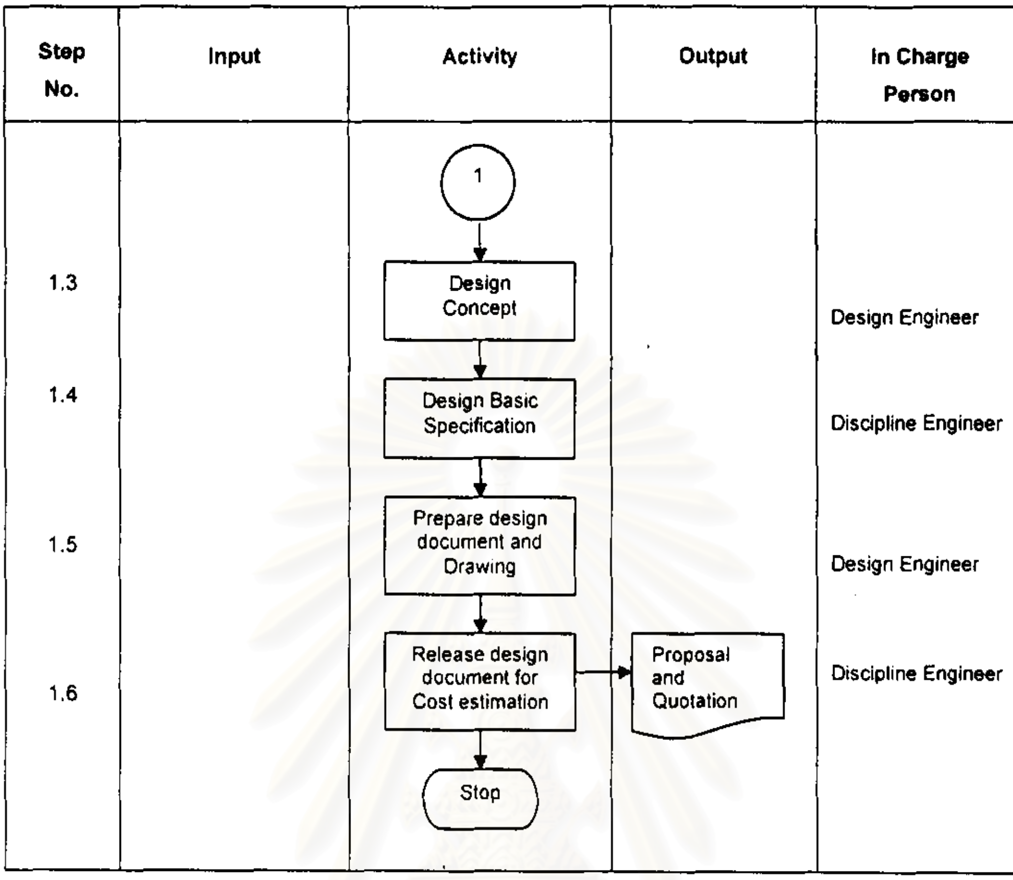

Figure 4.4 Procedure of design stage for pre-awarded project (Continue)

4.2.1.2 Design procedure for awarded project

After the project has been awarded, the purchase order and contract are passed to Engineering department. Six steps for design of awarded project is initiated as following:

Step 2.1 : Assign project engineer

The design stage for awarded project is initiated from Engineering Manager study information and assign a person who has experience in such awarded project to hand the project as being project engineer. Firstly, project log file is opened for filling all pertaining documents, including the proposed document describing equipment specification, cost estimation document, contract, correspondence with client and vendors, bill of material, payment schedule, work schedule, drawing, and design calculation. Input document consist of purchase order, contract, and proposed water treatment system.

Step 2.2 : Review proposed system

Project engineer, then, has reviewed the awarded proposal to comprehend the scope of work and also to revise some specification in order to meet the customer requirement. The process flow diagram is revised to be the first draft and passed to discipline engineer for design the detail to manufacture of each equipment and system, select the model of component and accessories, and design the electrical diagram. In this step, the project planning and scheduling is prepared as a tool for control the project execution.

Step 2.3 : Design detailed specification

Mechanical design engineer has to calculate the thickness of steel sheet used for pressure vessel fabrication, to provide assembled drawing for domestically assembled equipment such as Reverse Osmosis, and verify drawing and specification of local bought-out equipment (FRP storage tank), and to design piping system. Electrical design engineer has to design the diagram of control panel for controlling all equipment, to design the route of electrical wiring. Instrument engineer is selection the crucial instrument for monitoring and controlling function of individual equipment.

Step 2.4 : Prepare Process and Instrument Diagram

After equipment and instrument is designed and selected the actual Process and Instrument Diagram is updated for using in equipment installation procedure. In some project, after the detailed specification and P&ID are completely provided, they have to be submitted to the customer for approval. The approved document and drawing are returned back and proceeded the subsequent step.

Step 2.5 : Prepare Bill of Material

The output document from discipline engineer is the specific bill of material, BOM, and Project Engineer integrates them in the master Bill of Material that prepared. The equipment and component leadtime is updated in a project planning and scheduling for controlling the equipment delivery and period of installation procedure.

Step 2.6 : Prepare procurement document

The final activity of the design stage is to prepare procurement document in form of Purchase Requisition for equipment and component and to pass them to purchasing department after Project Manger has signed approval. However, the list of equipment requirement is checked in the store to ensuring that there are no existing equipment or component, which can be used for this new project.

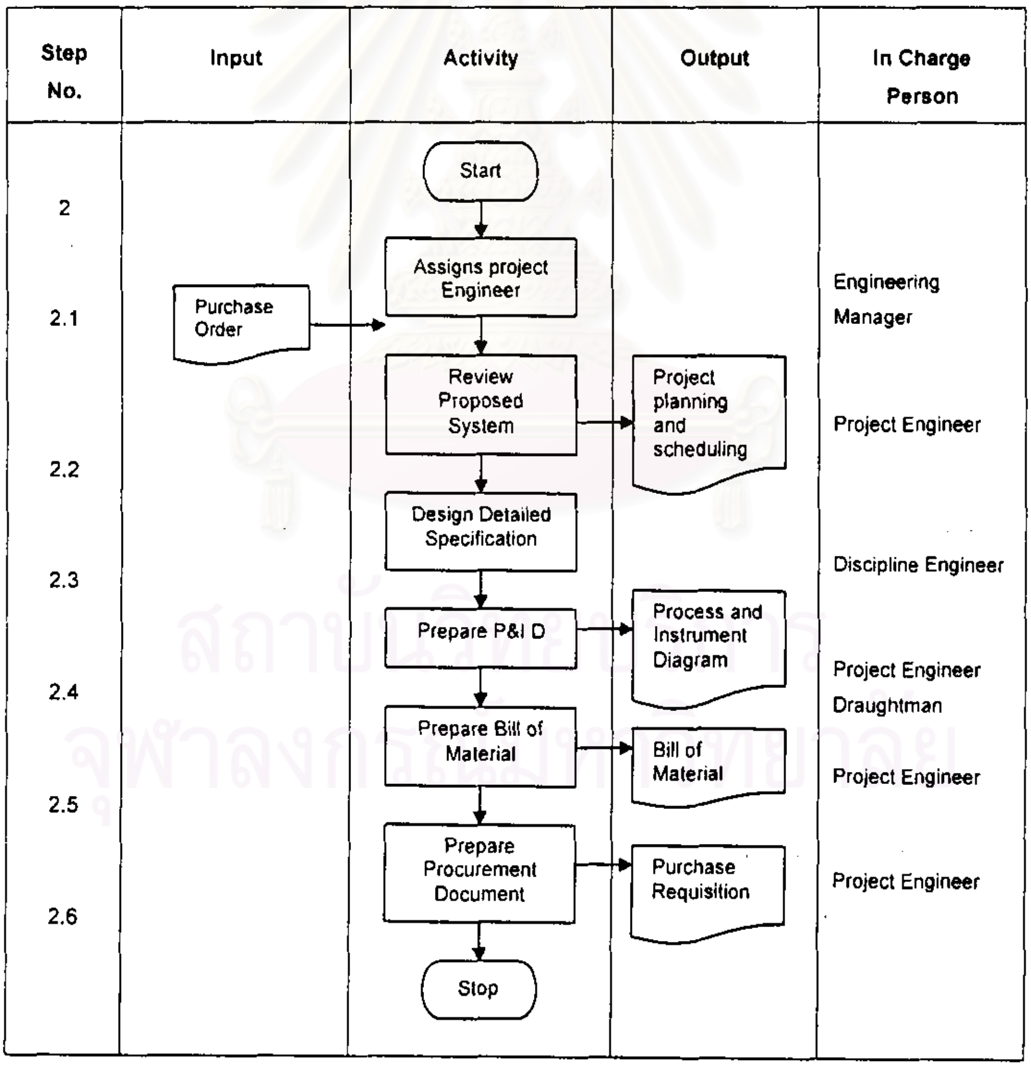

Figure 4.5 Procedure of design stage for awarded project

4.2.2 Equipment procurement procedure

There are five steps for procuring equipment and items to be used in the system.

Step 3.1 : Release Request quotation

As it has been stated that equipment to be procured is bought-out equipment and domestically assembled equipment, both vendor and subcontractor are going to be selected. This stage is initiated from purchasing department receive Purchase Requisition from Engineering department. Purchaser has called and faxed equipment specification to vendor and subcontractor to requesting the quotation.

Step 3.2 : Receive quotation

After purchaser has got the quotation and passed to project engineer, Project engineer and Engineering manager assess vendor and subcontractor. Important criteria applied for evaluating are equipment specification, equipment price and equipment lead time.

Step 3.3 : Select vendor and Subcontractor

In selection the vendor and subcontractor, the criteria used are equipment price, term of payment, and lead time. This selection usually perform by project engineer, and selected vendor and subcontractor then are negotiated the price by purchaser.

Step 3.4 : Release purchase order

Finally, whole purchase orders are released to vendor and subcontractor. However, during waiting for equipment, purchaser has followed the status of brought-out equipment in order to control the schedule of delivery, and project engineer has responsible to follow the status of domestically assembled equipment. Anyway, during the cost procedure, estimated Engineer has already request some equipment cost. Then the existing quotation is going to evaluate while waiting for other new requisition equipment.

Step 3.5 : Receive product

To receive the equipment, component, or parts used in the system is the final step of equipment procurement procedure. In receiving, equipment is usually delivered to two places, at site and at office, depending on the size of equipment. Basically, bought-out items are delivered to the office and are taken to the site for installation whereas fabricated or large-scale item are delivered directly to the site and are placed on the theirs layout plan.

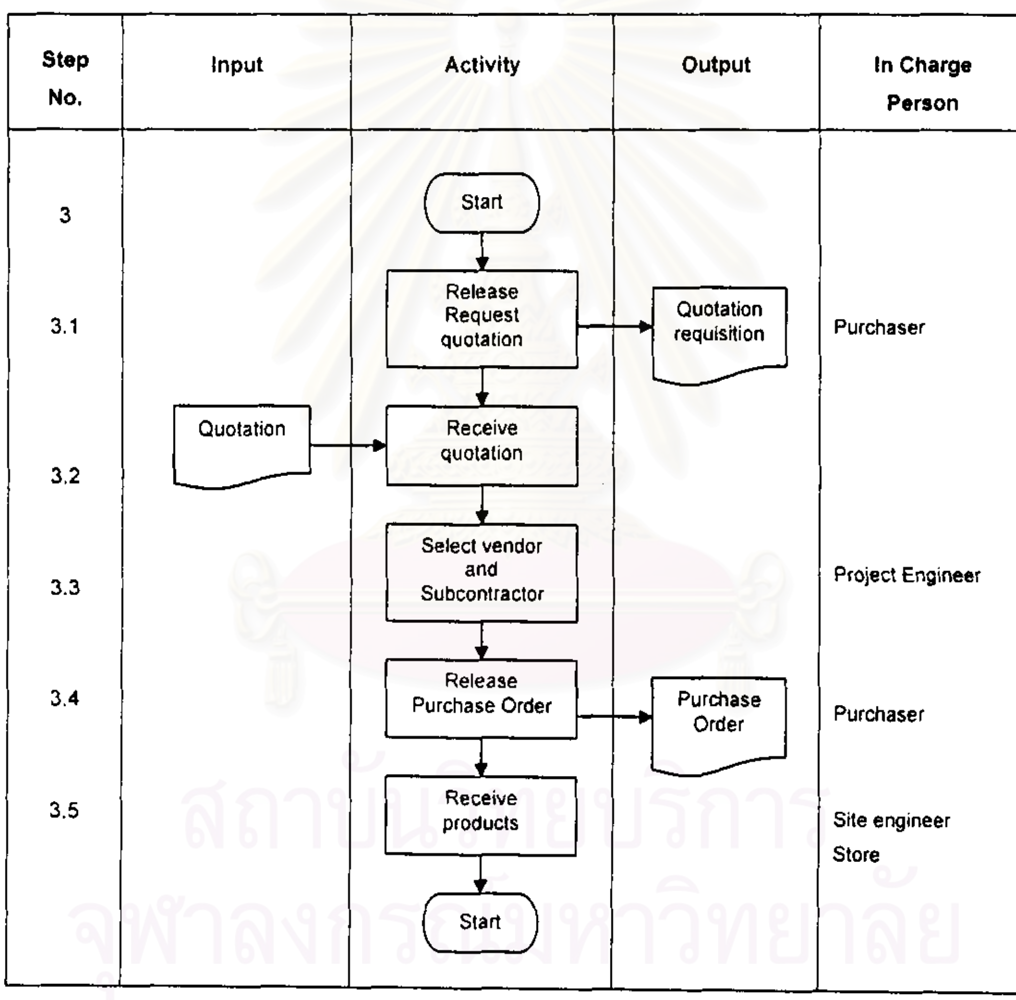

Figure 4.6 Procedure of equipment procurement stage

4.2.3 Equipment Installation procedure

This procedure is separated into six steps covering since provide updated layout until the commissioning.

Step 4.1 : Prepare final layout drawing

The first activity for installation stage is to survey the updated site layout in order to provide revised plan layout and to plan for the use of installation equipment. Site engineer is a person who has a responsibility to visit the site, whilst equipment are in delivery period. In addition, another intention of this operation is to ensure that site is ready for equipment delivery and installation according to the project schedule.

Step 4.2 : Equipment installation

For the large-scale items, normally, they are placed on their location and installed at the delivery date. On the other hand, bought-out items that are delivered at the office are taken to the site for installation.

Step 4.3 : Interconnection piping

After finishing equipment placement, then pipe, fitting, and valve will be installed to interconnect among equipment. However, pipe rack should be prepared during equipment installation.

Step 4.4 : Install electrical control panel and wiring work

Electrical control panel and wiring work might be installed contemporaneously.

Step 4.5 : System test run

An activity perform after all equipment has been completely installed including electrical wiring is functional operation testing. It performs equipment by equipment until the whole system function that include the control panel between equipment such as level switch control is tested accordingly.

Step 4.6 : Commissioning

The final project execution is commissioning procedure and hand over the project to the customer. However, warrantee period is started the day of customer acceptance and will be valid with in a year.

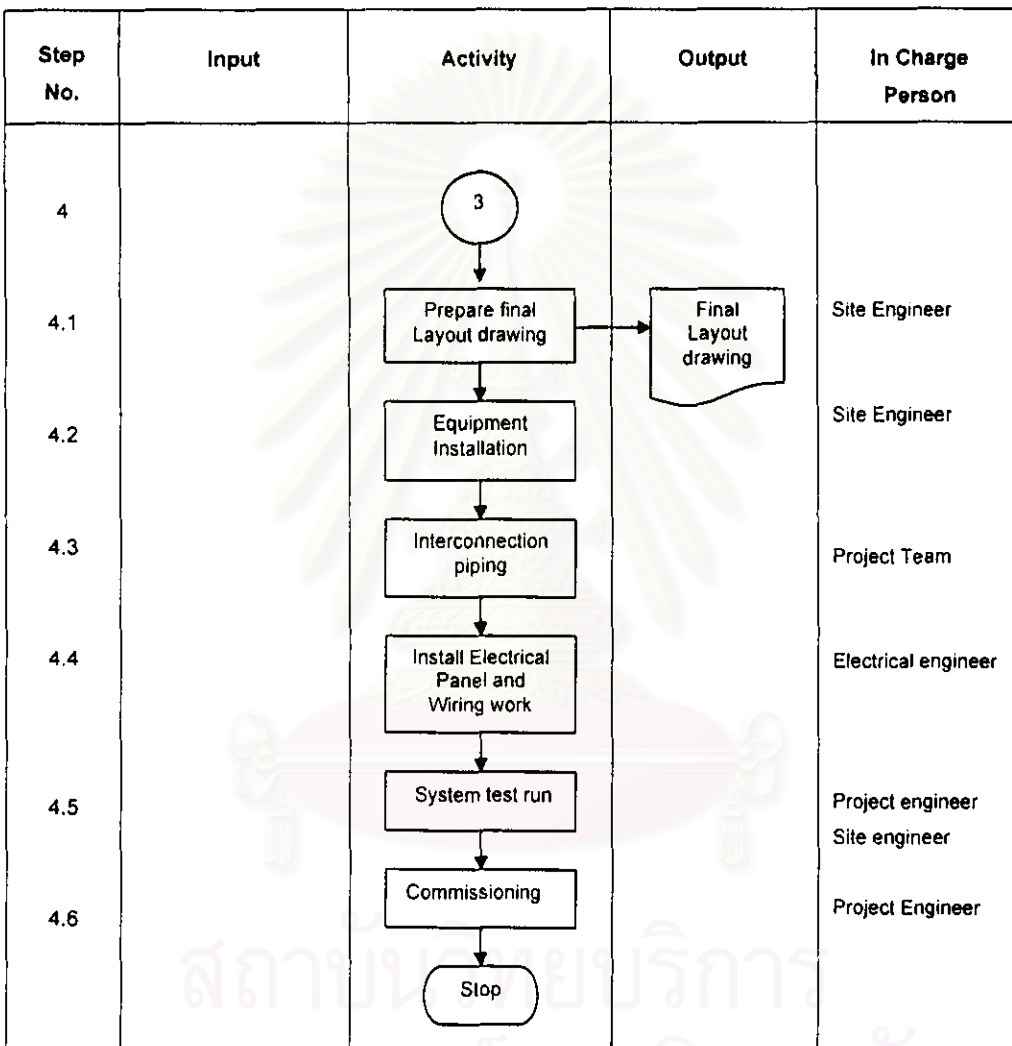

Figure 4.7 Procedure of equipment installation stage

4.3 Description of the Problems

Historically, in the project management most of the previous project faced the problem through the life cycle of the project, from design up to commissioning and operation. They regularly included the project schedule problem, the budgeting problem, the quality of work problem, and the customer dissatisfaction problem. Those problems appeared differently project by project and tended to appear in chain which one problem could be a cause of the other problems depending on their magnitude. For example, the shortage of component or equipment caused the project completion delayed in completion and brought about the budget overestimation since there were more overtime requirement. Another problem was the defect of installed equipment caused the project completion over the schedule because of repairing period and such over period made the project budgeting overestimation.

Virtually, causes of mentioned problems were both controllable and uncontrollable. Controllable cause usually incurred in many previous projects, which there probably was no any action to prevent although those can be defined and improved by the use of specific tool and/or techniques. On the other hand, uncontrollable causes were also found in the project but they could not be prevented and improved by any tools or techniques because those causes would happened by no prediction. Therefore, whenever any uncontrollable cause occur, it was inevitable.

In identification those happened problem quality of work was one of the controllable causes that made the project execution has failed. This was because each task was planed base on the high capacity of quality. Whenever any task was executed by the poor quality, the problem certainly incurred whether delay problem or quality problem or budgetary problem. Therefore, the quality management is an important procedure in the project management, since the project management tools and techniques could not be applied to improving and overcoming the quality problem areas.

In order to identify the characteristic and the magnitude of the specific problems, the performance of previous projects, SGT installed in 1998, was carried out as being case study.

4.3.1 The poor quality of work problem

By definition, the poor quality or failure of work means an unacceptable quality of work deviation from a specification of a measurement of quality that relates to reliability in performance (Madhav and Walter, 1985). Those failures then have to be improved whenever they occurred. There are several ways to improve those failure; rework, repair, modify, or replace by the new item, for instance. To preventing the occurrence of failure, specific quality assurance technique is required. For example, brainstorming, Cause and Effect diagram, checklist, and Failure Mode and Effects Analysis are tools applicable to assure that quality of work will consistency.

In SGT project, There were more failures incurred by the poor quality of project execution from design, procurement, and installation execution. They actually occurred whilst the project was continuously performing. The following are failures categorized by stage of operation into design stage, equipment procurement stage, and equipment installation stage.

1. The failure from the design operation

The failures or errors from design operation in SGT project were usually discovered while the execution was in the assembly stage or in equipment installation stage. It was true that those failures could not be found whilst the project was in the detailed design stage because of three reasons. The first reason was there was no real equipment to see during design and the second is design engineer did not clarify the specification by using the exact specification document. The final and critical reason was no design review procedure to verifying an error of design before passing through the procurement and installation operation.

In SGT project, there were more errors from the design operation in specifying the detail specification of equipment and component. They include the wrong standard of the connection of control valve, incorrect model of pressure vessel used for creation of assembled drawing, the wrong model application of pressure gauges, and mismatch of connection figure between stainless steel valve and pipe.

An incorrect standard of the valve connection was found while staffs were making face piping of the filter tank. The valve connection was designed in metric (DN) standard (50 millimeter) whereas pipe and fitting used in US standard (2 inches). As in comparison between two standards, the outside diameter of pipe (US standard) is 60.3 mm. whereas the inside diameter of connection (DN standard) is 62 mm. Since pipe must insert into the end connection, as a result there was vast gap between them (1.7 mm.). Such fault caused face piping task was pending until the corrective action to be carried out. In overcoming, the metric standard (DN) pipe that bigger than existing inside diameter of connection (63 mm. outside diameter) was provided and all existing adapters were re-machining to increase the inside diameter to 63 mm. for appropriate connection with DN standard pipe. Finally, connect these metric standard parts to the US standard by using the specific union ends; one side of that union end was US standard and another was metric standard.

In the detailed design process for Reverse Osmosis system fabrication, design engineer used the available specification documents for specifying more detail of component instead of requesting to individual vendor to sending the exact or updating specification document. Then, design engineer has designed and assigned a draughtman to draw an assembled drawing for subcontractor use for fabrication procedure. An error of detailed design was revealed when each component to be delivered. It was found that the model and figure of the existing pressure vessel was different from the original detailed design. Immediately, the specification document of received pressure vessel was returned back to design engineer for fabricated drawing correction, and provided additional component. There were three areas of failure that obviously found; the different position of feed water inlet port, the bigger size of inlet port, and more number of pipe support point (span). To solve such problems, the already part of machine must be replaced by the new part such as the SUS pipe route. Actually, there was scrap. In addition, some component could not be used to make the machine because they were improper size, and some component must be immediately prepared.

Once another important error in the assembly of Reverse Osmosis machine was the wrong model application of pressure gauge used to mounting on the panel. Normally, the standard pressure gauge used for the Reverse Osmosis machine was the back connection model, but nevertheless there are two differential applications of the back connection. The former is general back connection mounting in the piping line and the latter is back connection panel mouth type. The panel mount type has front flange for mounting its on the panel while the standard back connection has not such figure. Unfortunately, since these gauges were delivered over estimated period due to the order cancellation of the first vendor, and the panel for all instrument mounting including these gauges has already provided. By a result of incorrect model, the characteristic of pre-fixing hole was inappropriate, so the provided panel was moved out and made a new panel instead. The correction also produced the new modified connector for mounting these gauges on the panel.

Finally, the failure incurred in the assembly of Reverse Osmosis machine was the error in designing the connection type of stainless steel valve. Because of having two types of connection, thread and flange, a fault was easily incurring. From SGT project, all stainless steel valves were designed to be flange type but Design engineer designed pipe connection to be thread type. Though the model of these valves was indicated in the quotation before supplier delivery, they did not be rechecked the pipe connection figure in the drawing. The consequence was flange connection type to be delivered. By such failure, fabricated drawing, again, was redesign by the addition of eight flanges, pipe length reduction, and adjusts piping route. Eight stainless steel flanges then were provided.

2. The failure from equipment procurement

In the aspect of procurement failure it means that the procured equipment was not ready to be used when it has arrived. Defect of equipment, incomplete delivery of component, wrong model to be delivered, and inappropriate equipment to be provided was critical causes of this failure. Moreover, this failure also includes the cancellation from a vendor and no ordering of some equipment. Unfortunately, those failures were not discovered until the installation procedure has started.

The defect of equipment found during installation of SGT project was one of the four composite pressure vessels has vessel body leaned to one side. The defect caused the vessel could not able to operate under the normal pressure of designed system. This meant that a repairing work (unplanned task) was required. To use the defected vessel not only interconnecting pipe has certainly broken but pressure vessel also damaged. Pressure vessel and original base was separately by carefully cutting existing adhesive, removing old base, and cleaning the vessel. The base then was installed back by using a level on at least 4 points around the pressure vessel in order to assist the verification of the perpendicular of pressure vessel. The base installation guide in the instruction was step by step performed.

The incomplete delivery of equipment found in two equipment, FRP water storage tank and UF membrane. For the FRP water storage tank, it is usually being standard specification that it must have a level indicator to indicate volume of stored water. However, FRP storage tank supplied in SGT plant was no level indicator to be provided despite it was indicated in the drawing. Therefore, FRP tank maker has to produce it after it has been placed. It was actually that some installation work has been interrupted from that work such as the work for raw water pump installation. In this case, there was poor communication between sale department and manufacturing department. Salesman provided new drawing without level indicator and staff in production did not make it as manufacturing standard.

For UF membrane, there was some necessary component did not be delivered accompany the membrane module. UF system fabricator has found it during the fabrication. It caused the assembly work ceased and waited for that component to be delivered. However, that part has required less time to install in the machine, thus this was less affect on the delay of equipment completion fabrication.

Another failure in procurement was to receive the wrong capacity of two chemical tanks. Designed chemical tank capacity was 100 liters, which has 550 millimeters diameter. Those tanks were installed in the RO system, so designed area was fixed. Tanks were received in 200 liters capacity, which has 650 millimeters diameter. With such bigger one problem, not only overestimated budget for tanks but also the RO system fabrication drawing also was redesigned because of insufficient area.

Since most of previous manufacturers that Company provided water treatment plant for were semiconductor and electronic based manufacturing, the contamination of any specific lubricant such as silicone in the treated water was the serious problem. This was because all products of any batch using that contaminated water have been found the defect. Thus, there was procedure to detect such chemical in order to ensure that there was not any contaminating chemical in the used water. In SGT plant although all used valves were special ordered, silicone free models, there was a little silicone contaminates in the treated water. Consequently, the system was shut down for removing all valves to cleaning and testing. The cleaning procedure spent three days and required some cleaning chemical. In order to ensure that there was no contaminating lubricant, all prepared valve have to be cleaned before they would be installed in the plant even though there were silicone free model.

3. The failure from installation procedure

In the case study project there were three failures occurred during installation stage. The source of failures were both internal and external, that mean subcontractor. Failures were water leakage from UF machine, incorrect position of fixed instrument, and insufficient material to support FRP storage tank.

The first failure from installation procedure was the leakage of water from the UF machine. Since the UF membrane connector was made of PVC material that was easily broken, they required special tools for tightening. It was usually for UF system operation that when the position of valve has changed from the cleaning to servicing there was the back pressure within the membrane module. The pressure of water inside the module tried to flow outside. This caused the water leakage at the connection between adapter and pipe because of thread loosens. To solve the problem required those special tools to tightening before the UF system has operated. However, gradual tightening by general tools might solve such leakage but it takes a long time and risk in cracking.

There was an incorrect position of instrument, flow sensor, to be installed in the SGT plant. That position has insufficient recommended distance for measuring as describing in instruction manual. Flow sensor was inaccurate to measuring how much gallon of water flow in pipe per minute. This problem was solved by recalculating the required distance before and after the sensor position conforming to the manufacturer recommendation. The consequence of such failure was reworking and scraps producing.

The final error found was supporting base material of FRP storage tank collapsed. It is necessary for FRP storage tank to have supporting base. The reason was to raise drain flange from the ground. Type and quantity of supporting material to be used base on the contractor standard. For the SGT failure was insufficient quantity of supporting. One day after tank installation one side of tank inclined since there was less material on that side.

The figure 4.8 and figure 4.9 below have shown the rework occurred in each stage and the financial loss incurred in each stage of the project execution, respectively.

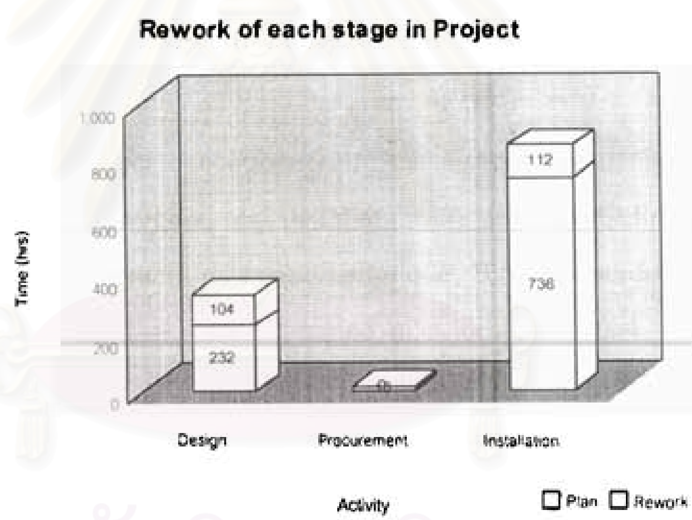

Figure 4.8 The Rework of each stage in Project
Source Data of XYZ company

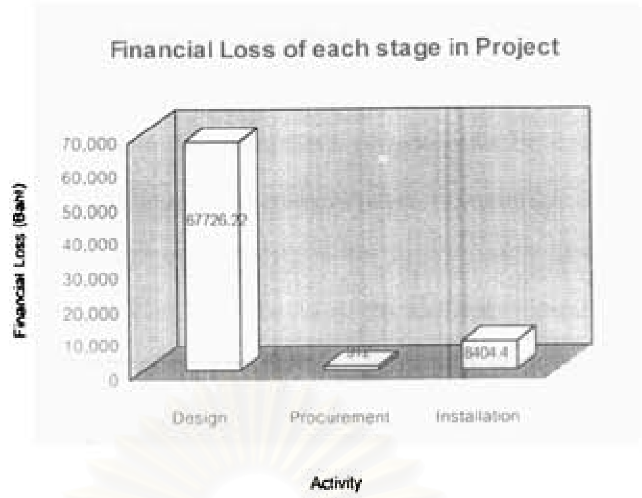

Figure 4.9 Financial loss of each stage in Project

Source Data of XYZ company

4.3.2 The delay of the project completion

Traditionally, in the project execution entire tasks including design operation, equipment and component procurement, and installation are regularly scheduled by the application of the project management tools and technique, Work Breakdown Structure (WBS). By such technique all tasks are separated into individual task and then are prioritized according to process of work for scheduling the project duration and allocating appropriate resources to the tasks. Each task is going to be sequentially executed from the first task to the final task. Having a linkage between the task in the project, the overspending of any planned task would make its linking task to completing late accordingly. Finally, of course, the entire spent time of actual project must over than the time of the planned project. As being the normal occurrence for all projects involved the construction and installation activities, the project schedule usually could not been tracked by the actual spent time owing to both controllable and uncontrollable factors.

The following were three areas of delay that cause the project completion later than the schedule.

1. Delay from equipment procurement

Equipment installed in the water treatment project can be categorized into two main types. The former is bought-out equipment that is usually supplied by either domestic or overseas vendors. This equipment is certainly made through the standard specification classified by model. The latter is domestically fabricated equipment that is mainly supplied by local subcontractor. Since this equipment is differentially used base on the specific design and application, it is made to the received order. There is no any vendor would fabricate or assemble it for stocking.

1.1 Bought-out equipment

The delay of Bought-out equipment has affected the project management execution because planned task linking to the late equipment could not be performed. It must wait until that equipment was delivered. A cause of delay in delivery was the longer lead time of production than commitment in the quotation. This makes the shipment procedure extension. Moreover, most delay problem incurred on the overseas equipment and certainly affected the import formality process as well. In addition to overspending leadtime, cancellation from the vendor has also impacted the operation of the project management. This was because purchaser had to rework the purchasing process since select vendor, provide purchasing order, and launch that order.

Item	Equipment Description	Delay (days)
1	Plastic Diaphragm valve	5 days
2	RO membrane and Pressure vessel	3 days
3	High Pressure Pump	3 days
4	Pressure Gauge	10 days

Table 4.1 The delay periods of bought-out equipment

Source Data of XYZ company

Note : Duration of delay period has counted from the subtraction of date that equipment was actually shipped out and the date that equipment must be shipped out.

1.2 Domestically assembled equipment

There were two domestically assembled equipment to be installed in SGT project: Reverse Osmosis System and Ultrafiltration System. Both systems were the cause of delay problem. Form the fabrication of Reverse Osmosis machine the failures from design and procurement were certainly the major effect. Redesign the pipe route, pressure vessel connection, and location to install chemical tank caused the fabricated drawing has to be recreated. Without correct fabricated drawing subcontractor could not further continuing fabricate the machine. Unfortunately, revised drawing required the additional component the substituted component, and the corrected part of machine. Lead time of those component affected the over spending of fabrication duration. Similarly, reworked to producing new panel also caused the fabrication lead time spent rather than planned. Finally, Reverse Osmosis machine complete assembles lather than the schedule two weeks.

For the UF machine, it could be completely fabricated on time although lacking of necessary component delivered from UF membrane manufacturer. This was because, usually, those parts use less time to install in the machine.

2. Delay from equipment installation

It is usually for all the water treatment plant installation that the scope of equipment installation covers from the site preparation up to the system is operated and all equipment function is tested its operation. Period of commissioning is actually one week, however it varies depending on the project scale. For SGT plant, installation procedure could not complete on the schedule since there were more unplanned events such as repairing for equipment defect, reworking for incorrect equipment's standard to be prepared, repairing for poor quality of installation work, and incomplete work.

From the mismatch between pipe and valve connection the solution was to change the connection of valve from DN standard to metric standard. Since these valves are the overseas products that actually require approximately three weeks for the lead time. In addition, the replacement fee charge and shipment fees were needed to pay as well. A proper way to solve that situation was domestically producing because it could save both budgetary and time. Unplanned work of this was to prepare the new connectors that actually spent one week.

As a defect of composite pressure vessel, repairing period required two days. One day was used for removing base, cleaning and preparing the base surface and another day was used for reinstalling the vessel on the base and waiting for the base settle.

There was poor quality of installation work that required the unplanned work. Firstly, to repair the FRP tank needs one day. The activity for joining the raw water pump with the FRP water storage tank has slipped for one day because supporting material of tank was no flat and made the tank to lean. Tank vendor spent one day for performing internal process and another day for reporting work at site.

During the functional testing, it was found the leakage of water from two pressure vessels of RO system that required a day to repairing and testing. The end adapter of the leakage vessel was removed to checking o-ring inside and to lubricating o-ring before reassembling. Also, the retaining ring was adjusted to fixing it with the vessel body in order to prevent the water flow out. Unfortunately, water still a little bit flow out between the end cap and the vessel body, thus more frequent reassemble were performed.

Before the system has started to test run the system, customer has found that the drainpipe was not installed up to the drain sump that customer provided. Installation team has extended the drainpipe from the completed install point to that provided sump. Though the distance of drainpipe was not so long, the difficult of installation and lack of accessories such as support caused this activity to complete delay one day.

After all the equipment and component have finished installation, there was a problem incurred whilst the system was testing run. Testing result from laboratory has reported that there was contamination of specific lubricant, silicone, in the treated water. Consequently, then system has been shut down and all PVC valves were removed out to cleaning. After all valves were installed back into their position, one of them then was taken to the laboratory for final checking. At the final, the system operated in the commissioning procedure again. However, such problem has caused the plant cannot operate for two days.

Item	Operation	Delay (days)
1.	Repairing the supporting material of Raw Water Storage Tank	1 day
2.	Re-machining the Female socket end and Waiting for a correcting pipe and fitting	5 days
3.	Re-assembly the end cap for checking the leaking of pressure vessel	1 day
4.	Repairing an incorrect alignment of Composite Tank	2 days
5.	Extend the drainpipe to the sump	1 day
6.	Cleaning all of PVC valves	2 days

Table 4.2 The delay period from repairing and reworking

Source Data from XYZ company

Note : Since the customer has changed the site location causing the project has slipped for 2 moths, the delay problem in case study project was a bit being the main project problem. However, those delay problems could be the majority problem in other project. Therefore, to overcoming and developing those problems are necessary to perform.

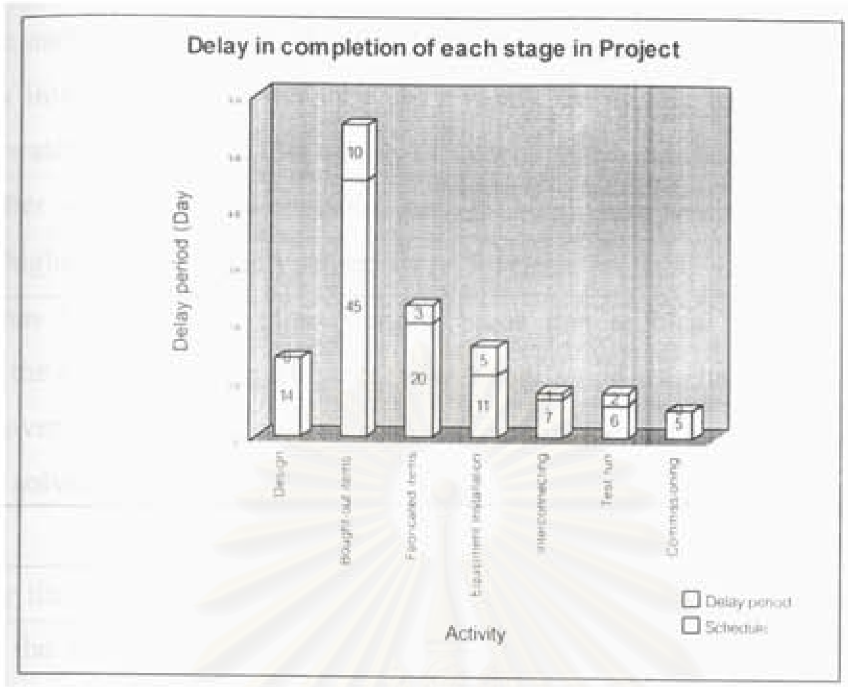

Figure 4.10 Delay of completion in each activity in Project

Source Data of XYZ company

4.3.3 The customer dissatisfaction

The final problem was the customer dissatisfaction. The majority causes of this problem in SGT project were the defect of equipment (e.g. the FRP storage tank, Composite pressure vessel) the consistency of equipment and system operation, technical specification, incomplete scope of work, and delay of project completion. For the defect of equipment, although they have already been solved during installation procedure, the customer has dissatisfied because repairing work caused the project completion delay.

It is observably that the consistency of equipment operation was discovered during equipment test run stage, commissioning stage, and also in the warrantee period. Having inconsistency of equipment and system operation, system shut down, more maintenance, and production loss are the events that customer does not need to occur. Such circumstance not only requires manpower and time to solve the problem but also requires cost of maintenance and loss opportunity to sale the products. Reverse Osmosis machine was inconsistency equipment since it usually produced the poor quality of treated water. After exploring, it was found that the slippage of connector between the membrane and end cap in the Reverse Osmosis pressure vessel caused the untreated water leak into the treated water tube. As a result, the mixing between the treated and untreated water produced the less quality of treated water, indicating on the conductivity meter. After servicing engineer solved such problem there was no leakage and quality of water higher. Unfortunately, there were fourteen pressure vessels, so the leakage problem has found on the other vessels. Since this problem was the first for the company, the exact cause of such problem was continuing searched after commissioning and hand over the project to customer. However, two months later, the exact cause was found and solved.

For the technical specification, there was more than twice a week of cleaning cycle for the Ultrafiltration machine. Actually, the system designed base on the information received from the customer and the operation requirement of customer, but the system operation has changed since the quality of water that influence to the machine fluctuated. Such poor quality caused the machine operated with high load and certainly the cycle of that machine must be shorter than expectation. The cleaning procedure was inevitable. Twice or three times a week of cleaning cycle made the customer and operator dissatisfy because not only time was required but cleaning chemical cost also was accounted. However, the machine can be designed to support once a week of cleaning operation although the variance of water influence but it must be done at the stage of design for equipment detail. The machine just changes the concept design from close or pressurized system to open system and changes the piping route, component, and instrument to support the ambient pressure operation.

There was an incomplete scope of work that made the customer dissatisfaction. Customer required the drainpipe to be installed up to the new drain sump, but installation team has installed this pipe to the old sump since site engineer has unclear this scope. However, after it has been found, the new installed drainpipe is installed up to that point.

The final customer dissatisfaction was the delay of project completion. Since this plant was the expansion of the production capacity, delay of completion caused there was no effluent water to supply the production machine that completely installed.

4.4 Identifying the possible causes of the stated problems

As it is difficult to finding solutions of the problems since sometime those problems may address only symptoms rather than the true cause of the problem, identifying causes as an intermediate step is seem to be better way (David, 1995). This is because it makes solutions both ease to find and also likely to address the problem fully. A common tool used for investigating problems, identifying and selecting key problem causes to address is "The Cause-Effect Diagram", which uses a specific layout to display the hierarchy of causes. In addition to investigate a problem, this diagram can also be used when the primary effect of a problem is known, but the causes are not at all clear (David, 1995). The following are the procedure to determining the possible cause of each stated problem by considering the manpower, machine, material, and method as being the primary cause areas. Then, add the secondary areas, which are to be addressed by further action, before adding actual causes, thus helping to ensure that all possible cause were considered.

4.4.1 Identifying the poor quality of work problem

On further investigation, it was found that the existing procedure of the project execution was not well organized and controlled. There were failures incurred in the design process owing to the manpower factor. Project engineer did not verify contract, designed the fabricated drawing by experience and available catalog instead of verifying equipment specification from exact catalog, and did not review the final designed specification before releasing the procurement document. In addition to the manpower factor poor data used for designing was a cause of designed specification could not meet customer requirement. The consequence of poor design, used incorrect specification document, was requiring redesign activity and also creating waste and scrap. Furthermore, the design document system was poor and it might be difficult to traceable when equipment has found the problem. In order to ensure that the failure of design will be found in the paper rather than found at site, the procedure of design must be re-establish by providing function of design control, design review, and design approval (for the large-scale project)

As well as design process, the procedure of equipment procurement was poor organized as well. This could be found that arrived equipment, especially bought-out equipment, and/or parts did not be inspected to verify the quality, defect, and performance. And also there was no inspection procedure for domestically fabricated equipment neither at factory before delivery nor at site before operation. Certainly, the defect of equipment, incorrect equipment, and incomplete equipment could not be found within the procurement stage. However, procurement document is an important tool in investigating the defect, incomplete, and wrong model because it described the detail of specification more than indication on the purchase order or invoice from vendor.

For the failure of installation, the lack of crucial installation document such as installation drawing and installation instruction was the significant reason because the incorrect work was easily incurred by experience of manpower. Lack of installation tools sometime created the fault from installation as well. However, installation control procedure is an importance to assist in controlling the quality of installation work.

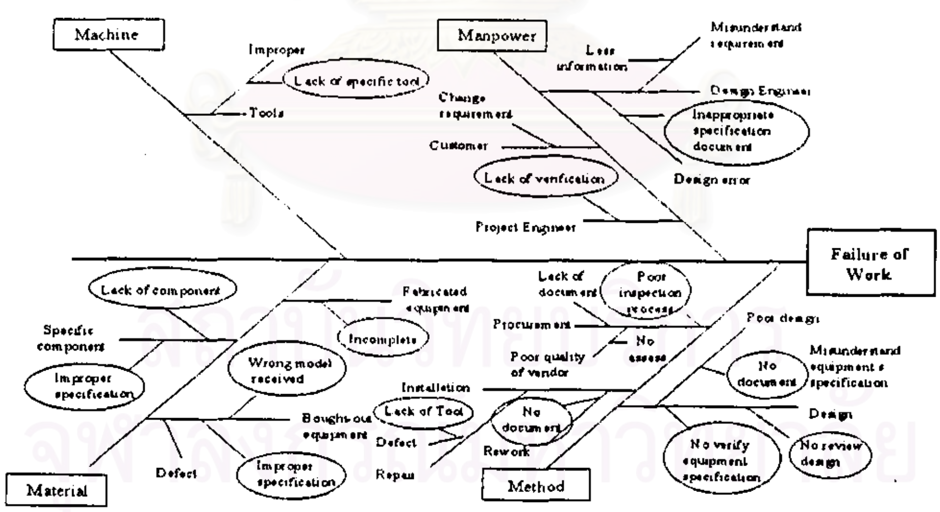

Figure 4. 11 Cause and Effect Diagram for Failure of work problem

4.4.2 Identifying the delay of project completion problem

From the project delay completion problem, it was found that there were poor performance of design activity, the poor organization of equipment procurement, and poor quality of installation work. These consequences affected the duration of the project schedule to be extended because of unplanned work package such as repairing for defect parts.

As it has the error in design fabricated drawing of Reverse Osmosis system, lead time of RO fabrication at factory has slipped two weeks. This was because subcontractor has waited for new additional component delivery, design revision, and revised drawing production. In identification, the primary design error was the principle cause of domestically fabricated equipment delay in availability at site. Redesign and redraw the revised drawing and reproduce the steel frame, were unplanned work packages.

Moreover, the equipment procurement process was not well organized; there was no inspection activity so defect and poor quality of bought-out equipment could not be detected immediately when they arrived. The store person just explored the evidently broken point and checked quantity, model, and figures of that equipment or component in order to affirm the description information indicated in the purchasing order. The specifics defect was not verified until it was used in installation and assembly phase. To repair the defect made the installation of equipment to be prolonged; for example, repairing the base of FRP pressure vessel cause FRP vessel installation work package delay two days. In addition, some overseas product did not indicate the accessories component in the purchasing order, but it shows in the packing list only. Therefore, the error in shipping such as lacking or wrong model has mostly been found in the receiving process, but it was discovered when it needed to use in the installation and assembly stage. Such waiting time cause the work to be extended until that component to be receipt.

The installation procedure was not prepared; there was poor standard process installation, drawing control, and bill of material used at site. Site engineer used his experience to assign team the installation method. To operate such procedure caused not only the delay of completion was met but also the defect of installed equipment was easily occurred. Without workshop drawing and bill of material, there was more frequently lacking of component such as pipe and fitting to be available a site. Therefore, some equipment could not be completely installed within the schedule. Furthermore, the defect of installation and failure in commissioning was the effect from the poor installation procedure as well.

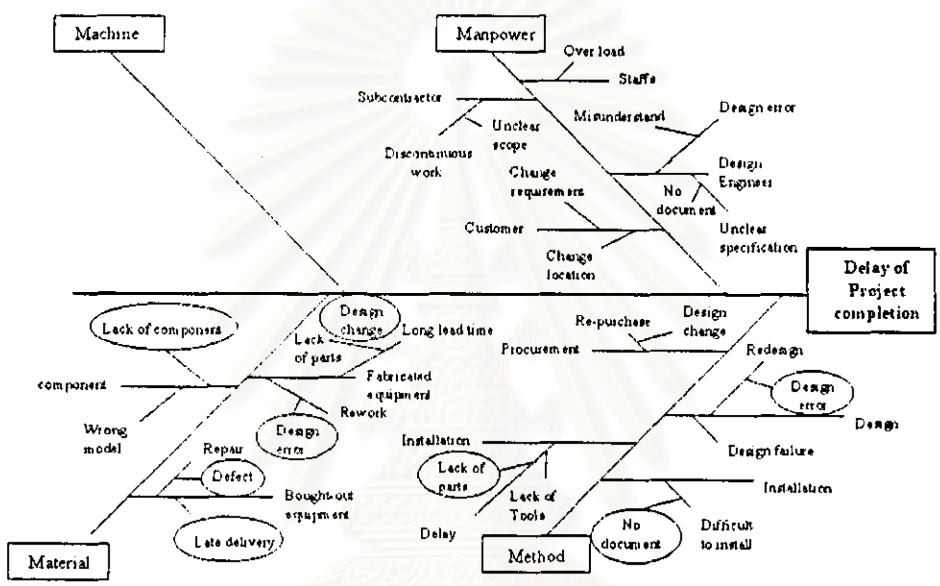

Figure 4. 12 Cause and Effect Diagram for Delay of project completion problem

4.4.3 Identifying the customer dissatisfaction problem

In identification the cause of dissatisfaction problem, it was discovered that design process was not well controlled. Design input data was less and insufficient information and it caused design output that mean the system and equipment operation has failed to satisfy customer. This was because equipment had frequent maintenance. Actually, the system was well operation under the condition of original design but when the condition has changed since the fluctuation of input data, the system needed more maintenance. Such maintenance brought about because of less safety factor. The design procedure, therefore, shall include design document control activity in order to ensure that input data will be sufficient and ease to understand the customer requirement. Moreover, lack of technical meeting with the customer makes misunderstand the technical specification between design engineer and customer.

In addition to design activity, the component and parts has become a cause of dissatisfaction problem as well. This was found in Reverse Osmosis machine that incorrect dimension, defect of part cause the connection between part and membrane failure and the system risks in operation failure accordingly. This incorrect dimension was an error in design of pressure vessel maker to matching with membrane manufacturer. Therefore, such event is difficult to prevent and control because there are more membrane model in each maker and more model of pressure vessel in each maker as well. The best way is keeping in record of the matched couple and verifies the part number of parts indicating in material list guide whether correct or not. However, pre-loading of membrane into the vessel in order to measuring the gap was a way to detect such problem.

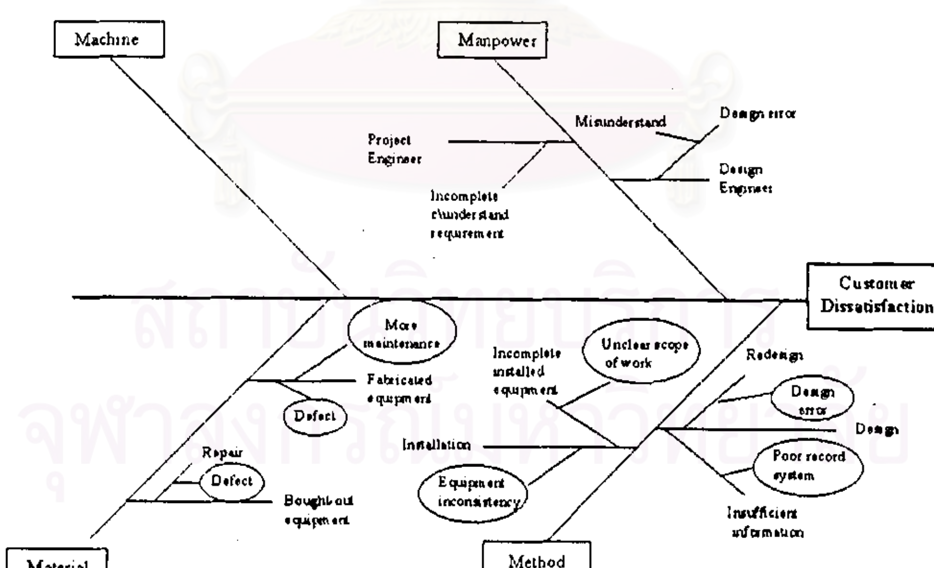

Figure 4. 13 Cause and Effect Diagram for Customer dissatisfaction problem