Project Management With International Applications

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A Major Technical Report

in the

Center For Building Studies

Faculty Of
Engineering And Computer Science

Presented in Partial Fulfillment of the Requirements
for the degree of Master of Engineering at
Concordia University
Montréal, Québec, Canada

August, 1982

ABSTRACT

PROJECT MANAGEMENT WITH INTERNATIONAL APPLICATIONS

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The Project Management on a project starts with a good project organization which has developed objectives and is dedicated to achieving these objectives through well developed procedures. These procedures have been described in this paper and cover the following areas:

1) Estimating;

2) Cost Control;

3) Planning and Scheduling;

4) Engineering;

5) Procurement;

6) Construction.

The emphasis in this paper has been given to the selection of a qualified Project Manager. A good Project Manager is knowledgeable in engineering and construction, is able to delegate work, and is able to maintain good working relations with the client.

Emphasis in this paper has also been placed on team work. Various disciplines such as Project Management Services, Engineering, and Construction each have functions of their own but the decisions made at their level affect each other. This factor demands an effective communication system between these disciplines, and again, a good Project Manager ensures that the information flows from one department to the other at the proper time and without interruption.

Because a great number of new projects are being developed in third world countries, more and more North American companies are getting involved with overseas work. This report describes some of the difficulties encountered on international projects which impact on project management personnel and the project management process. Issues treated deal with geography, culture, religious and economic conditions which demand extra effort on the part of Project Managers in the achievement of their objectives.

ACKNOWLEDGEMENTS

I wish to thank Dr. A. Russell for having reviewed the draft of this report and making many very valuable comments and suggestions which helped improve its structure and content.

I would also like to express my sincere appreciation to the various individuals in the construction industry for having participated in the interviews and through their experience and opinions on Project Management.

I owe a great deal of thanks to my former employer, SNC Inc., and present employer, Bechtel Canada Limited, particularly Mr. Jim Folk for allowing me to study the literature and benefit from Bechtel's worldwide project management experience. Without this help, this work would have taken a much longer time to complete.

Special thanks go to Aileen Newman and Pam Fearon for doing an excellent job of typing the draft and proof reading and helping me meet the deadline.

Finally, I would like to acknowledge my gratitude to my wife, Aziza for her patience, encouragement, and support. Without her help, this program would not have been possible for me to complete.

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PURPOSE

The overall objective of this report is to provide the reader with an orientation to all phases of project operations and explain the methodologies of an engineering, procurement, and construction (EPC) type organization from the award of the project through completion and turnover to the client. It will cover the project organization, project management services (covering planning and scheduling, estimating, cost control, and procurement), Engineering, Construction, and various concerns on international projects versus domestic projects. In summary, it will include all the steps necessary to successfully complete a project awarded to an EPC company, whether domestic or international. Since increasing numbers of Canadian and U.S. firms are involved with overseas projects, an attempt will be made to present here the material which is being used or has been developed by those corporations which have successfully completed several international projects.

The report material is organized into five (5) chapters as follows:

Chapter 1: Project Organization will introduce the concept of the project management organization, the team concept, leadership roles, and responsibilities of the project manager.

Chapter 2: Project Management Services will cover planning and scheduling functions, estimating and cost control, and procurement. It will also explain the functions of the PMS manager and PMS organization.

Chapter 3: Engineering describes the engineering design, drawings, and specifications. Specifications will be identified as requirements and standards for material, equipment, quality of workmanship, etc. It also covers the environmental services provided by an EPC firm and factors considered when providing these services.

Chapter 4: Construction will discuss the responsibilities, functions, and activities of the construction phase of a project in general.

Chapter 5: Domestic Versus International Projects covers the general aspects and approaches to be considered during the construction of an international project and differences in the following:

- Planning and scheduling;
- Procurement of equipment and materials;
- Camp facilities;
- Staffing and teaming; and
- Legal, tax, and insurance systems.

CHAPTER 1

1.0 Project Organization

1.1 Objectives

The objectives of this chapter are as follows:

- Define project management and develop an organization chart;
- Describe the responsibility concept of the matrix type of organization as well as the meaning of the project management team concept;
- Give a list of items representing project personnel responsibilities;
- Describe the characteristics of a good project manager;
- Explain the problems associated with Foreign Projects;
- Explain why job location and duration have an impact on job staffing and why an enterprising individual prefers to work on a project; and
- Explain the contract and its obligations.

1.2 Projects

Projects are well defined efforts to produce certain specific results at a particular point in time and at a certain cost. They may be called programs, task force, teams, ad hoc committees, or other titles and they exist in every business, industry, and governmental level.

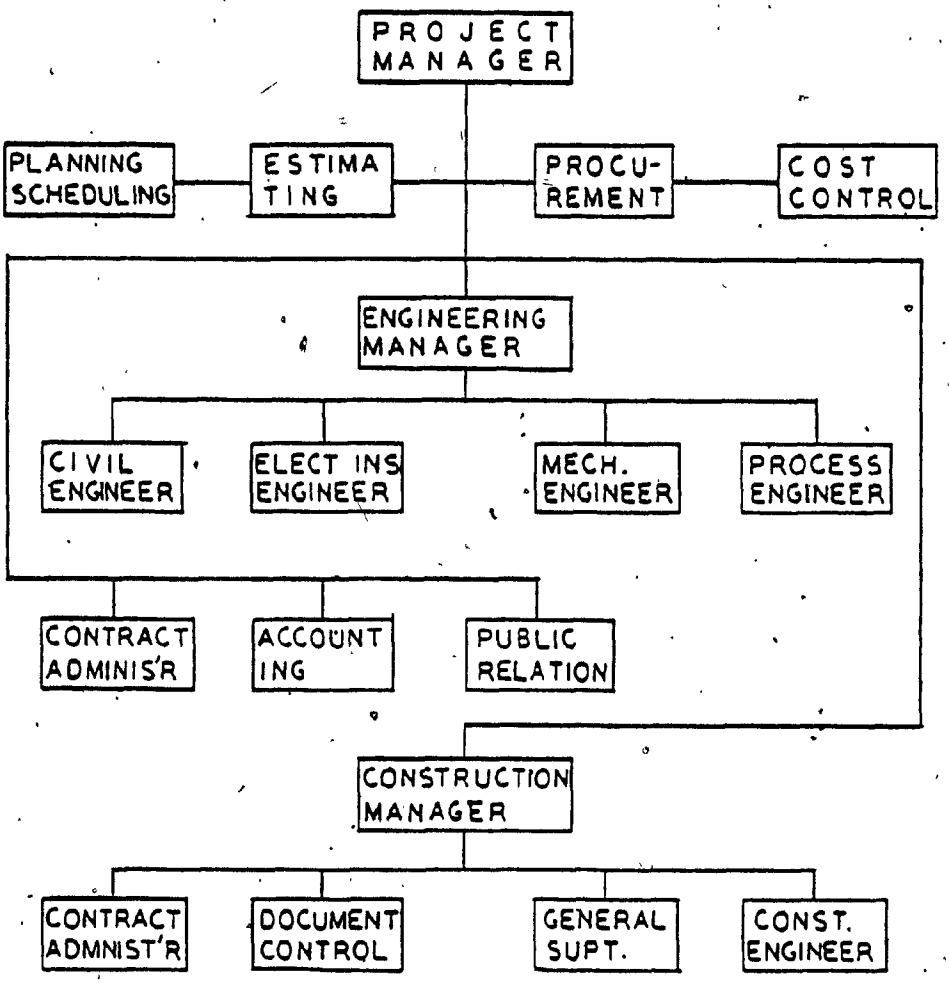
Effort in this report will be limited to construction projects. Such projects are common in the sense that they all need a basic effort to organize teams to provide the engineering, procurement, and construction (EPC) services.

1.3 Project Management

Commercial project management is usually a compromise between two basic forms of organizations . . . pure project management and the more standard functional alignment. In aerospace and construction companies (see Figure 1.1), complete responsibility for the task, as well as the resources needed for its accomplishment is usually assigned to one project manager. In very large projects, the organization he heads, which will be dissolved at the conclusion of the project, resembles a regular division, relatively independent of any other division or staff group.

Figure 1.1

ORGANIZATION CHART



The central figure in any project organization is the project manager who is accountable to both top management and the client for delivering acceptable performance within schedule and budget constraints.

The related services such as planning, cost control, and engineering are provided by the professionals usually drawn from the respective functional departments. However, these professionals who become members of the project team for a particular project, report directly to the project manager, during the duration of the project.

The concept of project management, therefore, cuts across and in a sense conflicts with the normal organizational structure. Throughout the project, personnel at various levels in many functions of the business contribute to it.

1.4 Characteristics of a Project Manager

The success of the project management philosophy centralizes in the Project Manager and a successful project manager must have the background which would enable him to carry on the functions of project management to a profitable conclusion. Though the project manager's previous experience is apt to have been confined to a single functional area of the business, he must be able to function on the project as a kind of general manager in miniature.

He must not only keep track of what is happening but also play the crucial role of advocate for the project. Even for a seasoned manager, this task is not likely to be easy. Hence it is important to select an individual whose administrative abilities and skill in personal relations have been convincingly demonstrated under fire. The background of the individual can be divided into the following three categories:

1. Executive

   Decision making
   Setting objectives, policies, and plans
   Anticipating problems
   Organizing

2. Management

   Control of time
   Problem solving
   Budgeting and scheduling
   Reporting

3. Leadership

   Communicating
   Monitoring

Figures 1.2, 1.3, and 1.4 illustrate the impact of emphasis on each of the above categories on the organization.

See reference No, 5.

Figure 1.2

IMPACT OF EXECUTIVE EMPHASIS UPON THE ORGANIZATION

POOR PROJECT MANAGER	GOOD PROJECT MANAGER
OBJECTIVE, POLICY, AND PLANS	
Unrealistic and deterministic	Realistic and dynamic
People know but do not believe and cannot achieve	People know, believe, and achieve
ORGANIZATION ORDER	
Crises, panic, and crash action	Urgent, expedited and unified action
Work done and redone	Work done once
Dealines missed and policy violated	Deadlines met within policy
Routine actions suspended	Routine action continued
PERFORMANCE OF PEOPLE	
Few key people involved doing work for long hours	Few key people available for guidance and decisions
Working levels keep busy	Working levels kept busy
Responsibility Usurped by crises	Responsibility delegated through channels.
PERFORMANCE OF PROJECT MANAGER	
Always too busy fighting fires	Never too busy fighting fires
Forced to make routine decisions for lack of policy and thresholds	Uses policy and thresholds to force routine decisions by organization

Figure 1.3

IMPACT OF MANAGEMENT EMPHASIS UPON THE ORGANIZATION

POOR PROJECT MANAGER	GOOD PROJECT MANAGER
MANAGEMENT PROBLEM SOLVING	
Does subordinate problem solving in work he knows	Does his own problem solving at level for which he is responsible
Approves subordinates	Delegates problem solving
Problem solutions in work he does not know	Responsibility within his organization
ORGANIZATION ORDER	
Usurps responsibility and authority delegated to subordinates	Maintains delegated responsibility and authority of subordinates
Maintains two separate management information systems. One informal system for himself. Another eyewash system to impress his superiors	Maintains a single integrated management system for his organization and he uses it
Continuous slippage and overruns	Occasional slippage and overruns
PERFORMANCE OF PEOPLE	
Reduction of sense of responsibility	Willing acceptance of responsibility
Indecisive and frustrated	Decisive and satisfied
PERFORMANCE OF PROJECT MANAGER	
Indispensable	Key people to carry on
Always too busy in meetings	Never too busy to meet
Over cautious in work he does not know	Confident of people in work he does not know
Over interested in work he knows	Patient with people in work he knows

Figure 1.4

IMPACT OF LEADERSHIP EMPHASIS UPON THE ORGANIZATION

POOR PROJECT MANAGER	GOOD PROJECT MANAGER
CONTRIBUTION FROM PEOPLE	
Responsive participation	Responsible participation
Passive resistance	Active cooperation
Information withheld	Information contributed
ORGANIZATION ORDER	
More procedures and measurement	More policy and encouragement
High price paid for contributions	Low price paid for contributions
PERFORMANCE OF PEOPLE	
Uniformed, frustrated, defensive and negative	Informed, satisfied, cooperative, and positive
Motives aligned with incentives	Motives aligned with objectives
Develops an ability to stay out of trouble	Willing to accept more responsibility
PERFOMRANCE OF PROJECT MANAGER	
Assumes people are unwilling	Assumes people misunderstand
Blames his subordinates	Blames himself
Attempts to demand	Attempts to improve
More authority	More communicative
Relies more on material incentives	Relies more on moral persuation

See reference No. 4

1.5 Problems Associated With the Foreign Projects

Every capital investment project, whether domestic or foreign is subject to the restraint of three inter-related parameters--quality, cost, and time--each of which influences and is influenced by the other two. The objective of project management is to devise, define, and implement a program in which the relationship between these three parameters is optimized, i.e., the desired quality level is attained at the lowest practicable cost and in the shortest practicable time.

For foreign projects, many of the activities of a project manager involve factors of crucial importance which are not normally encountered on domestic projects, but which must be taken into account in the planning phase because of their influence on the time and cost parameters of the project.

Some of the areas, which a project manager of North American origin finds it more difficult than a domestic project are discussed in the following.

1.5.1 The Contract

In addition to the usual parties, there are almost inevitably two additional people involved in the contract on a foreign project--an agent and a local lawyer.

The agent will have participated in the original identification of the project and continues to assist in the contract negotiations. The input of the local lawyer will be required to act on behalf of the company to ensure that the contract respects the local laws and will be able to provide invaluable advice on all aspects of doing business in that country. In addition, there are other considerations which must be borne in mind while negotiating a contract on a foreign project such as:

1.5.1.1 The scope of work must be clearly defined. Simply intent of the contract provisions does not exist in foreign countries. The cultural difference usually results in two different interpretations of "intent" and what is accepted as normal business ethics here in Canada can be a totally alien concept in some foreign countries.

1.5.1.2 In the contract, care has to be taken to ensure that proper allowance is made for factors which will affect expatriate personnel and their families.

1.5.1.3 The contract will very often be written in a foreign language and great care must be taken in translation of the documents.

1.5.1.4 Canadian consultants will have to be prepared to contractually agree to be subject to the laws of the foreign country and to accept the dispute which will be resolved under foreign jurisdiction.

1.5.1.5 Payment terms must be defined in the contract and factors such as foreign currency rate and arrangements for the transfer of funds from one country to the other must be written down.

1.5.2 Fees and Budget

The cost of doing the work on a foreign project is usually more than the client's or project management organization's expectations. The contract should of course establish the mark up and contains an estimate of the fees to be charged for the work to be done. However, some additional costs are involved which must be included in the estimate or budget. Such costs include:

- Agent's fees and lawyer's fees
- Bank guarantee and bonds
- Insurance
- Taxes in foreign country
- Communications costs
- Local office expenses, in relation to personnel assigned overseas. Such items include:
  - Salary premium
  - Hardship allowances
  - Living allowances
  - Automobile
  - Relocation costs
  - Passports, visas, and work permits
  - Medical and psychological testing
  - Storage of furniture, etc.
  - Education of children
  - Personal taxes and tax equalization
  - Additional leave benefits
  - Compassionate leaves
  - R & R (rest and recuperation)
  - Emergency evacuation
  - Costs of replacing personnel

See reference No. 12

1.5.3 Other Factors

Project management in its application to foreign projects, should accommodate several other factors, a detailed discussion of which is beyond the scope of this report. These factors include the language of the local workers and suppliers, local customs, religious holidays, taxes (import duties, etc.), local existing or non-existent safety regulations, codes and standards, local engineering practices and methods, transportation, and so on.

Based on the foregoing discussion, a checklist can be drawn up for purpose of project planning (Table 1.1).

Table 1.1

Government Regulations

What are the legal requirements covering the following items? How are they administered, and by what government?

- Permission to construct a plant
- Import permits or restriction
- Currency restrictions
- Permission to operate a plant
- Design and testing of boilers and storage tanks
- Design and operation of hoists and mechanical equipment
- Design and testing of electrical equipment and distribution systems
- Design and testing of structures
- Safety requirements and fire protection
- Water and air pollution, sewage and waste disposal
- Liability for defective design or construction
- Zoning and local building laws, and jurisdiction of local government
- Working conditions and social facilities
- Insurance requirements, liability, and accidents

Table 1.1, Continued

Taxes and Duty

- Sales taxes, invoice tax, and business taxes
- Import taxes and duty tariffs
- Duty exoneration, if any
- Importation procedures, where and how cleared, and documentation required
- How are applicable duty tariffs determined and can the determination be appealed
- Restrictions on temporary importation (construction equipment)

Labor

- Laws relating to employment of nationals
- Laws relating to employment of foreigners
- Working hours, overtime, legal holidays, vacations, and benefits

Local and National Code Standards and Practices

- Stuctural design
- Pressure vessel design
- Electrical equipment and distribution systems
- Standards, if any, for pipe, valves, and fittings. Commonly available to what standards?
- Commonly used structural and architectural materials
- Underground piping, both utility and sewer
- Reinforced concrete design and placement
- Paving and road surfacing materials and practices

Table 1.1, Continued

Procurement and Commerce

- Commercial practices such as payment terms, supplier financing, escalation, and penalties
- Price stability
- Capabilities of local fabricators
- Local supply houses and stock carried
- Who/what are the representatives or service facilities and parts supply on behalf of major equipment manufacturers (compressors, pumps, instruments)?

Transportation

- Access to site by rail, road, and water; limitations on load or size
- Port facilities, rail and road transportation from potential foreign supply source
- Transportation costs and port charges
- Contacts with reputable forwarding agencies

Construction

- Labour availability both skilled and unskilled
- Local construction contractors, their experience and capability
- Availability of construction equipment and rental rates
- Temporary hiring, manpower agencies, cost, and availability of locally hired construction staff
- Customary insurance carried by contractors

Table 1.1, Continued

General

- Contacts with local industries for general information on their experiences
- Availability of soils, concrete, quality control, and other testing facilities
- Language
- Local customs
- Local driving regulations and habits
- General attitude of the people towards foreigners
- Local religious and statutory holidays.

See reference No. 6.

CHAPTER 2

2.0 Project Management Services

2.1 Objectives

The objectives of this chapter are:

- To explain the role of a project management services manager in an EPC firm with his standing in the organization;
- To explain the planning and scheduling functions, and different types of schedules;
- To explain the Estimating and Budgeting functions and explain different types of estimates;
- To explain the cost control functions of a project methodology;
- To define Procurement's worldwide functions and responsibilities;
- To explain what material management involves; and
- To make a comparison between Procurement's activities on domestic and on overseas projects.

2.2 "PMS" Project Management Services

When an owner is seeking assistance in organizing the resources which would put his dreams of a business venture into reality, he has to look for the following two things:

2.2.1 Funds to pay for the services such as engineering, equipment, and materials and construction; and

2.2.2 A work force to do the job of management, engineering, construction, and commissioning.

The owner generally concentrates on the financial aspects of the project and hires the individuals or independent companies to perform the rest of the work.

Because the financing of a project is a two-way game between the one who borrows the money and the one who loans it, both want to keep track of time. The owner wants to know exactly when he will be able to generate profits so that he can start payments on the loan and the lender wants to make sure that the money invested will definitely bring repayment of the loan within a specified time.

It is that mutual interest of the owner, the lender, and to some extent the engineering firm to plan, estimate, and adopt certain procedures which helps ensure an orderly use of the funds (Cost Control).

In the context of project management, Planning, Estimating, Cost Control, and Procurement are called Project Management Services. These services are provided by the individuals trained in such fields under an umbrella organization called PMS (Project Management Services Department) within the organization of the EPC firm.

2.3 PMS Manager and His Functions

Unlike a project manager, a PMS manager heads a group which does not provide its services to only one project but to all the ongoing projects in the company. The PMS manager, therefore, is a central figure in the organization who has to liaise both with top management and with all the project managers activily engaged on the projects. It is this characteristic which makes his job different than a project manager, who may be responsible for only one or two projects.

A PMS manager knows that he has a greater responsibility than a project manager in the sense that the services he provides will be carefully scrutinized by the client as well as by his own management.

The functions of a PMS manager may be described as follows:

2.3.1 Assist the Personnel Department by recommending the right person for planning and scheduling, estimating, cost control, procurement, PMS Department, and arranges the appropriate guidelines or courses for those who need to upgrade their knowledge.

2.3.2 Acts as a salesman for his department to both the project managers and prospective clients.

2.3.3 Develops new methods or improves existing procedures in the PMS Department.

2.3.4 Assumes the responsibility in the event of any conflict between his subordinates and other functions.

2.3.5 Ensures the quality of work.

2.4 PMS Organization

A PMS manager is a general manager and under him there are three or four functional managers who are responsible for the individual activities such as planning, scheduling, estimating, cost control, and procurement (Figure 2.1).

Each functional manager has senior staff members working directly under him as project planners, project estimators, and so on. This structure further extends to the senior, intermediate, and junior levels for each discipline as shown on Figure 2.1, PMS Organization Chart.

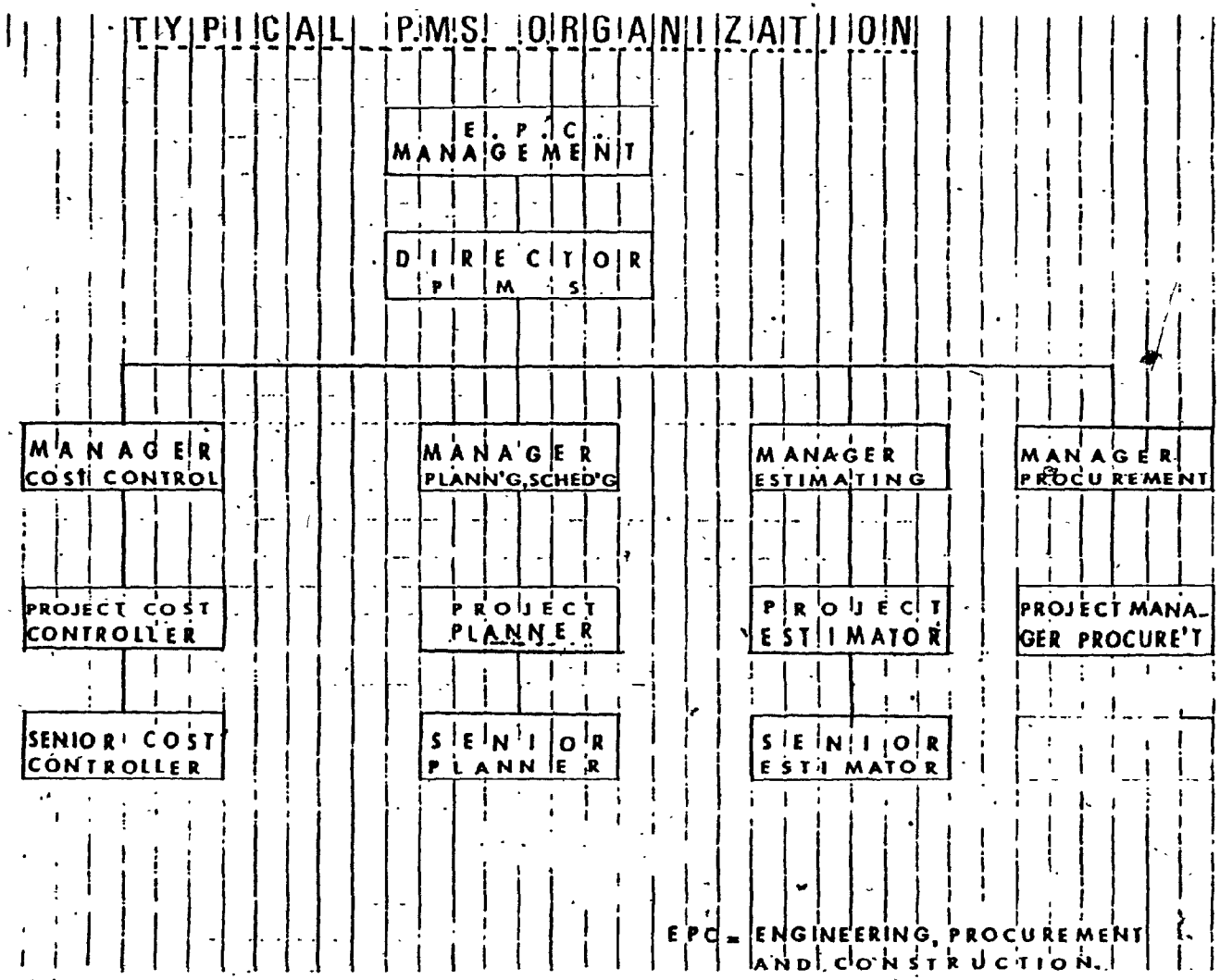
2.5 Planning and Scheduling

Planning is the devising of a workable scheme of operations which is designed to accomplish an established objective when put into action.

Planning and scheduling must be done by qualified people who are well familiar with the type of field work involved. Also, input should be made by the project manager, manager of engineering, each discipline engineer, estimator and cost controller, as well as procurement people in the development of a practical work breakdown or work sequence.

It is also essential that the people in the field be involved in the planning because they are more knowledgeable than anybody in the home office with respect to site conditions and potential problems which may delay the construction of the project. It is important that the people in the field be expected to implement the plan to make it work.

Figure 2.1


TYPICAL PMS ORGANIZATION
E.P.C. MANAGEMENT
DIRECTOR PMS
MANAGER COST CONTROL
MANAGER PLANN'G,SCHED'G
MANAGER ESTIMATING
MANAGER PROCUREMENT
PROJECT COST CONTROLLER
PROJECT PLANNER
PROJECT ESTIMATOR
PROJECT MANAGER PROCURE'T
SENIOR COST CONTROLLER
SENIOR PLANNER
SENIOR ESTIMATOR
EPC = ENGINEERING, PROCUREMENT AND CONSTRUCTION.

2.6 Planning and Scheduling Procedures

Planning and scheduling services are performed for the project by an engineering, procurement, and construction planning group which monitors and updates all project schedules and related reports.

At the beginning of each project, an overall schedule is established which shows beginning, completion, and milestone dates. Basic engineering, procurement, and construction schedules are then prepared to outline various features of the work. A more detailed breakdown of the schedules and mechanisms for coordination of subschedules, updating of the overall schedule and monitoring and reporting of schedule activities are the responsibilities of the field cost and scheduling supervisor.

2.7 Detailed Construction Schedules

A field scheduler is assigned to work directly with the jobsite superintendent and engineers to establish detailed short term working schedules for day-to-day control of operations. At regular intervals, construction personnel update their schedules and forecast their progress. Division services personnel use this information to refine the project schedule.

2.7.1 Critical Items/Action Report

The progress of the project is evaluated on a periodic basis by making sure critical activities are proceeding according to the most up-to-date schedules. The conclusions are discussed in the critical items/action report which identifies all critical or potentially critical activities and the effect their slippage may have on the project. This report is distributed to project team members for review and comments on the course of action to be taken. These comments are subsequently incorporated into the critical items/action report for monthly presentation to management and the client.

The information is included in the project scope book to establish an adequate base for cost and schedule trending, project planning, and estimate preparation.

2.8 Procurement Status Report

The procurement status report provides information on the status of major procurement items. A computer printout or manually prepared schedule shows original schedule, current forecast, and actual dates for the complete procurement cycle from specification to delivery.

At the time of contract award, division services personnel give the project personnel a standard listing of all purchase orders that may be required for the project, together with anticipated lead times for all activities in the procurement chain. Engineering personnel review this listing, delete non-applicable items and add any other they feel should be included. From this renewed listing, an initial procurement status report showing durations and completion times for all activities is prepared and forwarded to engineering and procurement personnel for review. On completion of the review, approved engineering and procurement control documents are issued to the project.

On contract management work, each contractor must submit with his bid a schedule of operations required to perform construction activities in accordance with a detailed schedule in the contract.

2.9 Milestone Summary Schedule

This schedule includes the activities which establish major milestone dates for engineering, procurement, construction, and start-up activities on the project.

Preliminary material release and installation curves are included and manpower curves are prepared to match the projected schedules.

Milestone summary schedule is updated monthly based on information obtained on a continuing basis from other departments. The schedule and accompanying curves are submitted to project management for approval and are then sent to the client. It provides a base for additional detailed project schedule development and progress monitoring.

2.10 Detailed Schedules

Detailed schedules for engineering, procurement, and construction are made within the framework of the milestone summary schedule. They often consist of from 500 to 3,000 activities. They are developed, modified, and updated throughout the life of the project. These detailed schedules of activities allow for manpower scheduling and coordination between the various project organizations.

Schedules are formally reappraised several times during project development and a gradual evolution of detail occurs as completed designs become available. Except for these evolutionary changes, schedule revisions are not made unless:

- Time objectives are changed by management/client agreement;

- Changes in scope of work impact on the schedules; or

- Major replanning of sequence or timing of work is required.

Updates and refinements of the detailed schedules are used to continually update the project schedule.

2.11 Detailed Engineering Schedules

Engineering schedules are detailed by each design group under the general supervision of an engineering planner. They provide a basis for intergroup coordination and engineering manpower scheduling. At regular intervals, individual engineering groups update their schedules and forecast their progress. Division services personnel use the engineering status report to refine the project schedule.

2.12 Construction Schedule

The construction schedule details the operations required to perform construction activities in accordance with a detailed schedule in the contract. Such a schedule includes:

- A detailed bar chart with milestones;

- Manhours and quantities (units) by weekly activities;

- Computed productivity (manhour units) planned by week by activity;

- Names of supervisors by activity with dates and work plan; and

- Equipment planned by activity with dates and work plan.

The contractor's schedules are reviewed by the field planning and scheduling supervisor and the respective field engineers.

Depending on the size and complexity of the contract/subcontract, construction schedules may be done using either bar charts or the critical path method. Schedules for contracts/subcontracts of any size must designate at least five milestone events so that progress may be factually evaluated at those points.

The contract requires the contractor/subcontractor to periodically update his construction schedule. Any changes are carefully reviewed in relation to the overall schedule. Major changes are discussed with the contractor/subcontractor to determine if they are realistic and if additional effort is required to mitigate the effects of the changes.

The basic field duties required for planning and scheduling are:

- Update all schedules at least once a month;
- Prepare daily and weekly schedules of activities on direct hire work in cooperation with the superintendents;
- Coordinate all contract/subcontract schedules;
- Review with Procurement scheduled delivery dates for material and equipment so delivery schedules can be updated;
- Identify schedule problem areas and verify these with the general superintendent;
- Report any schedule problems to the field construction manager along with a description of remedial steps taken or to be taken;
- Notify contractors/subcontractors of schedule deficiencies and ensure the evidence is received demonstrating the manner in which the deficiency will be corrected; and
- Post a current updated construction schedule in a prominent location.

2.13 Estimating and Budgeting

The estimating discipline or cost engineering group develops a succession of estimates and budgets for the project. While the form and detail of an estimate depends on the degree of project definition and the status of design, procurement, and construction at the time of the estimate, the overall estimate is based on the current technical scope document and the established scope of services. When approved by the client, it is used to establish updated budgets for the project team.

Trend programs are established in both the division and the field to monitor the design and construction phases of a project. By analyzing trends, they provide a means for early detection of problems. They allow the project team to:

- Reduce plant costs;
- Optimize plant design by taking corrective action before the design is fixed; and
- Provide tracking of project development to avoid unplanned late costs.

The project trend program is initiated after the trend base is prepared and continue until engineering is essentially complete. In support of the project trend program, the project cost engineering group provides:

- Interproject cost information;
- Identification of industry trends;
- Technical direction and administration for cost trend engineers; and
- Assistance in estimating and reviewing trends.

Cost trend engineers work with the project engineering staff to monitor continuously and report deviations from the approved budget that affect cost, scope, or schedule. Trends with their estimated cost and schedule effect are reviewed monthly with the project team.

Monthly trend reports are prepared and submitted to the management and the clients project manager.

The cost trend program in the field is maintained by the field cost engineer who holds periodic meetings with lead field personnel from each department. This cost and schedule early reporting system is designed to monitor and update the project scope of work, costs, and schedule to include changes in work items identified in the field.

The intent is to provide warnings of potential cost increases, to document scope changes, and to allow communication of cost information to all responsible personnel. The field construction manager is responsible for construction input to the cost trend program.

Quantity changes are the responsibility of engineering. Items concerning quantity changes, productivity overruns, changes in temporary facilities, etc., are discussed with the field cost engineer to determine the impact on the project cost and schedule and to assess causes of any problem.

2.14 Types of Estimates

Generally there are five kinds of estimates, which are used by most EPC firms. These estimates are relevant to the amount of engineering completed. They are:

- Order of magnitude estimate;
- Preliminary estimate;
- Definitive estimate;
- Control estimate; and
- Tender check estimate.

Description of Estimate Types

2.14.1 Order of Magnitude Estimate

This is a basic and vague kind of estimate which is prepared at the conceptual stage of the project.

For order of magnitude estimate, usually the historical data from a similar kind of project is used, adjusted to suit the dimensional data of the new project. This estimate provides a quick and approximate value for a broad assessment of the cost of the project or part of the project to be used by the client.

2.14.2 Preliminary Estimate

A preliminary estimate is prepared when an improvement in the concept of the project objective is attained. This estimate also uses factorizing procedures with some conceptual quantity evaluation.

The use of the order of magnitude and preliminary estimates vary from one client to the other, but generally the preliminary estimate constitutes a basis for negotiations with the financial institution for obtaining loans whereas the order of magnitude estimate provides an idea about the cost of the project to the client.

2.14.3 Definitive Estimate

A definitive estimate is produced when preliminary engineering is substantially completed and final design is advanced to about 20%. This is the most important cost estimate during the life of the project. It establishes the target budget and serves to define the scope of the project. The target budget is used as a yardstick for cost control purposes. The project manager and his team have to live with this estimate. Consequently, a spirit of responsibility is created in the team by having all project engineers review and agree with the section related to their discipline. This estimate is also reviewed in depth by the EPC firm and the client.

2.14.4 Control Estimate

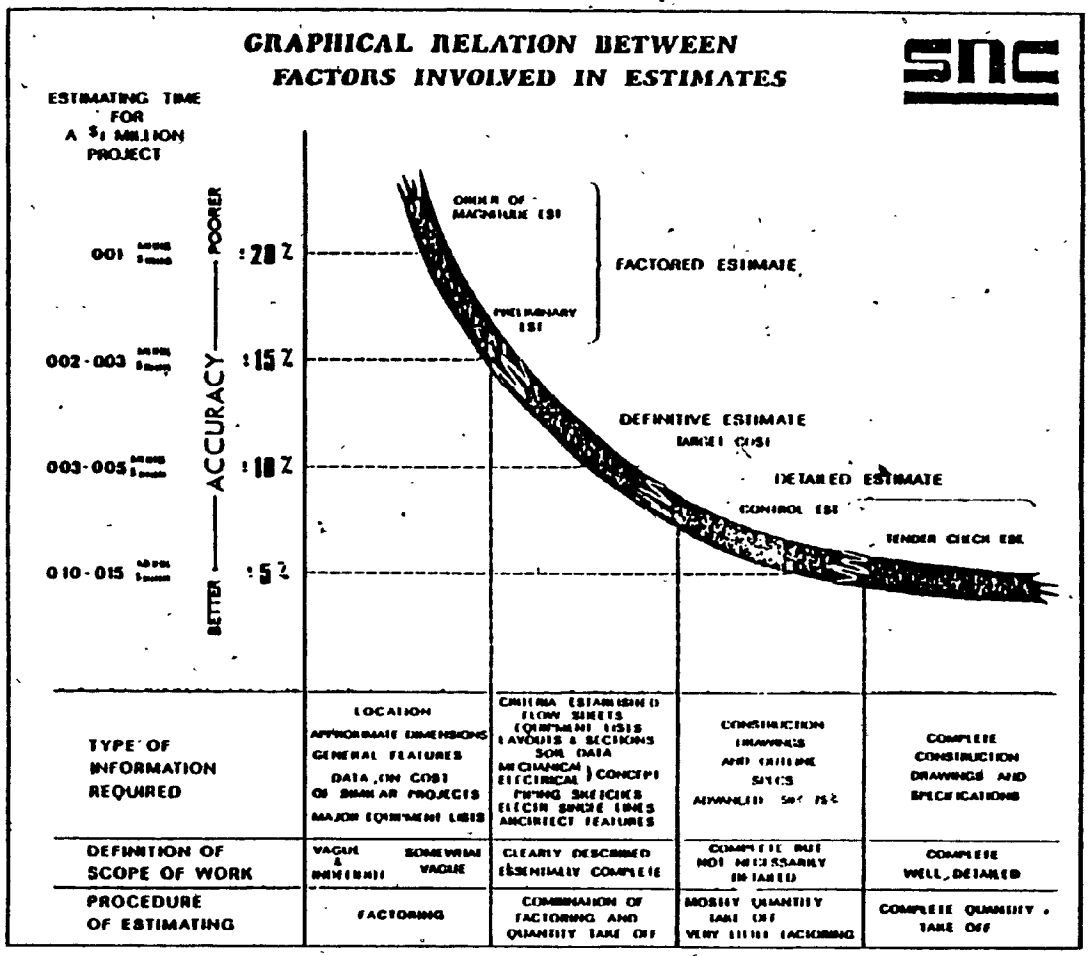
This kind of estimate usually covers a part of the project and is prepared at approximate intervals of the design phase to control design through "design to cost" concept. The results of this estimate should reveal the scope variations and the estimate to complete the work of the package for which this estimate was compiled.

2.14.5 Tender Check Estimate

This estimate is prepared for each package, using the same information which goes to the contractor for tendering purposes. The purpose of this estimate is to ensure that the design was in fact compatible with the target cost (Definitive Estimate) and, also, it serves as a tool for the bid analysis.

During the lifetime of the project, several other estimate types such as productivity analysis, various alternatives, etc., are prepared but, although they have a bearing on the decision making for local assignments, the have no major effect on the overall budget. The five kinds of estimates, as discussed above, are presented in a graphical manner in Figure 2.2.

Figure 2.2



2.15 Cost Control

Cost control is an essential tool of project control. Throughout the life cycle of the project, the project management team develops the ideas for controlling the cost of the project. The function of cost control on the project is provided by a project cost controller and his job is not only to control the cost, but also to alert people who are associated with the control of expenditures through design, procurement, and construction, of any deviation from the original budget.

2.15.1 Cost Control Methodology

Cost control is implemented through continuous monitoring of each phase of the project and includes cost keeping, contract monitoring, and cost forecasting.

2.15.1.1 Cost Keeping

A cost keeping system is established at the start of the project for cost control purposes during field operations and for capital asset accounting purposes at the end of the project.

2.15.1.2 Contract Monitoring

A contract monitoring report is used by management to review contractor/subcontractor performance of construction work, and to maintain a construction schedule in the field and to minimize slowdowns which might be caused by late discovery of cost changes.

2.15.1.3 Cost Forecasting

Periodic cost forecasts are prepared in the field under the supervision of the field cost engineering supervisor. Forecasts are made for all costs including engineering, construction management, procurement, division support, contingency, and fee. The field requests each department's forecast just prior to the cutoff date.

Engineering and other departments monitor their respective budgets by forecasting manhours on a monthly basis and comparing these forecasts with actual manhours expended.

Reasons for variations from the budget are analyzed and brought to the attention of management. Deviations are incorporated in the trend program.

Field cost engineers are responsible for monitoring field expenditures, evaluating them in relation to construction progress and identifying problem areas. In the field, cost control implies holding within prescribed limits those portions of project costs for which field construction supervisory personnel are responsible. To establish that job costs are within prescribed cost limits, it is necessary to maintain quantity and cost information which can be evaluated and projected to the end of the job. Cost control, therefore, includes the timely accumulation and interpretation of cost and quantity information, its correlation with specific construction operations, and the extent of physical completion of individual blocks of work.

Not only is cost control a tool used by field supervision and management to evaluate job performance and recognize and correct deviations, but it is also a source of information from which to develop standards for planning and estimating future work. The field construction manager is responsible for overall field costs and for delegating the responsibilities for individual costs to appropriate members of the field organization.

Overall costs for a project are determined by the coordinated efforts of division and field personnel in preparing estimates and forecasts of work. Once costs are established, budgets are prepared. Field work is monitored against these budgets. Whenever possible, the person responsible for controlling costs (cost controller) is also given the responsibility for estimating or forecasting total costs.

As work progresses, costs are monitored, controlled, and analyzed using some of the following tools:

- Performance reports;

- Manpower and distributable manhour reports;
- Quantity and unit rate reports;
- Salaried and hourly based manpower curves;
- Construction equipment schedule;
- Reports on material and equipment costs;
- Subcontract reports;
- Monthly field trend reports; and
- Semi-annual forecasts.

The control effectiveness is achieved through:

- Fully indoctrinating all responsible parties on the methodology of the project control system;
- Establishing an effective system for accurately reporting manhours, quantities, subcontracts, and material costs;
- Establishing a regular schedule of cost review meetings; and
- When indications of cost increases become apparent, determining the causes and taking remedial action.

For cost control, construction personnel are responsible for:

- Manual manhours;
- All distributable costs (materials and subcontract manual and non-manual manhours);
- Construction department manhours;
- Scope change manhour adjustments;
- Labour productivity; and
- Construction methods and techniques.

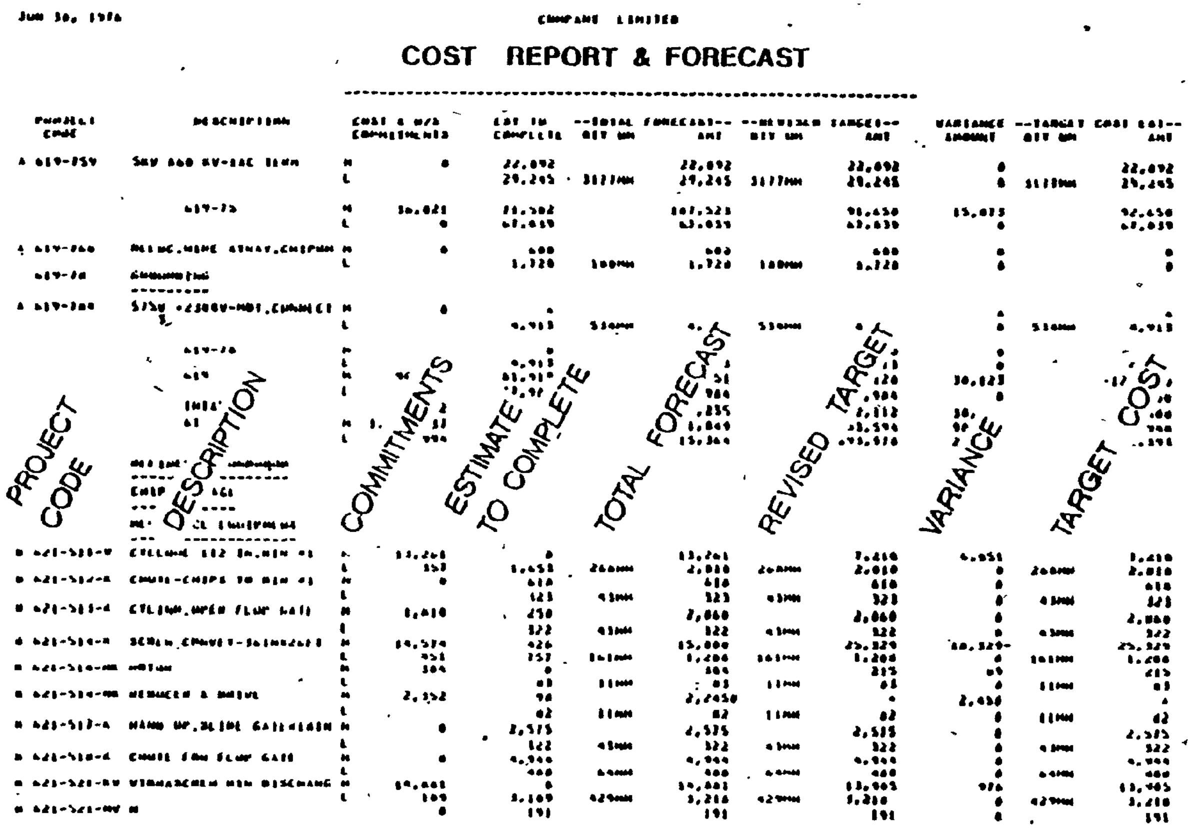
After project award, the project estimator provides a schedule and an estimate of total project costs including manhours. The project/construction manager is responsible for reviewing and approving the estimate. Once the project estimate has division approval, budget sheets for field use are processed.

When work starts in the field, division construction personnel prepare formats and supply the field with a list of required cost and schedule reports. The division construction controls group reviews the field reports and compiles statistics denoting trends, monthly production rates, etc.

After construction activities get underway and budgets have been issued to the field, forecasts are prepared periodically until project completion. The field construction manager and his staff are responsible for these forecasts which are reviewed by a visiting division cost engineer. The field generated data are incorporated by division personnel into a management presentation.

After approval, the project manager, assisted by division services personnel, incorporates the approved forecast data into a client presentation.

Figure 2.3



Source: SNC INC. (Project management services)

DEC 31,1976

Figure 2.4

CONTRACT NO.

HOLDBACK & PAYMENT STATUS

P.O. NO.	SUPPLIER	DESCRIPTION	P.O. AMOUNT	GROSS CLAIMS	HOLDBACK DEDUCTED	PAYMENT TO DATE	UNPAID BALANCE
2091E110	ALLEN BRADLEY LTD	SHV 250 HP STARTER	19,010.97	0.00	0.00	0.00	19,010.97
1	ANTHONY DE ROSE	MILL BLDG FOUNDATIONS	52,426.00	52,426.00	0.00	52,426.00	0.00
14	ANTHONY DE ROSE	FORM REBAR & CONC PLACE	509,135.00	486,260.00	72,940.00	413,320.00	95,815.00
15	ANTHONY DE ROSE	CONCRETE SUPPLY	132,415.39	132,415.05	19,862.25	112,552.80	19,862.59
1E109	ARTHUR B LEITCH	AFTERCOOLER & MOIST SEP	2,241.01	1,415.31	0.00	1,415.31	825.70
110ME103	BAUER BROS CANADA	72 INCH AIR SEPERATOR	5,885.00	1,100.00	0.00	1,100.00	4,785.00
87ME103	BAUER BROS CANADA	WHIZZER & PULVERIZER	142,806.00	40,460.00	0.00	40,460.00	102,346.00
106ME128	BAUER BROS CANADA	FINE CLASSIFIER	3,389.96	3,389.96	0.00	3,389.96	0.00
ME101	BEL-ART PRODUCTS	POLYETHYLENE JARS	1,022.00	0.00	0.00	0.00	1,022.00
M-2ME188	BLACKWOOD HODGE	CONVEYOR BELT	44,035.06	0.00	0.00	0.00	44,035.05
105ME151	BOMAR & BEMIS	MILL BAG SEALER	44,726.00	13,933.[illegible]	0.00	13,933.53	30,792.47
200ME153	BUCHANAN & ASSOC.	SHELLEYS PLA	5,560.06	5,560[illegible]	0.00	5,560.06	0.00
[illegible]	[illegible].G.E. CO LTD	INFRA RED H[illegible]	89.00	[illegible]	[illegible]	0.00	89.00
[illegible]	[illegible].E. CO LTD	MOTORS & [illegible] CABLES	101,679.62	47,0[illegible]	[illegible]	47,00[illegible]	60,673.00
[illegible]	[illegible]NADIAN CO [illegible]	FIRE PUMP [illegible] ROLLER	3,63[illegible]15	3,[illegible]	[illegible]	3,0[illegible]	544.67
[illegible]	[illegible]ANADIAN C[illegible]	[illegible] NO [illegible] FARIER	7,7[illegible]	[illegible].00	[illegible]	[illegible]	7,[illegible].80
[illegible]	CARBORUNDUM	MILL [illegible] AT COLLECTOR	32,[illegible]	[illegible].00	[illegible]	[illegible]	32,[illegible]
[illegible]	CARBORUNDUM	4 COMP[illegible] COLLECTOR	54[illegible].00	[illegible].00	[illegible]	[illegible]	30[illegible]
[illegible]	CARBORU[illegible]	DUST [illegible]CTION	8[illegible].95	[illegible].00	[illegible]	[illegible]	[illegible]
[illegible].9	CARBOR[illegible]	MILL [illegible] DUST COLLECTOR	1[illegible].00	[illegible].53.65	[illegible]	[illegible]	[illegible]
[illegible].01	CON [illegible]IER	CAC[illegible]	[illegible]73.16	[illegible].813.94	[illegible].63	[illegible]	[illegible]
[illegible]8	CEN-[illegible]ECTIONS	S[illegible] DECK	[illegible]494.52	[illegible],931.00	[illegible].00	[illegible]	[illegible]
[illegible]ME130	CHI[illegible] BLOWER	[illegible] CYCLONE FAN	[illegible],516.19	0.00	0.00	[illegible].00	[illegible].19
[illegible]ME118	CHI[illegible] BLOWER	[illegible] DUST CONTROL FANS	4,434.52	0.00	0.00	[illegible].00	24,[illegible].52
246ME125	CHICAGO BLOWER	BA[illegible] DUST EXHAUST FAN	6,266.02	0.00	0.00	0.00	6,266.02
16	COMSTOCK	UNDERGROUND PIPING	13,541.02	13,541.02	2,031.15	11,509.87	2,031.15
20	COMSTOCK	PRIME CRUSHING CHUTE	3,626,319.23	417,881.39	62,582.00	355,199.39	3,271,119.84
23	COMSTOCK	ELECT SUBSTATION	26,821.00	21,484.91	3,222.56	18,262.33	8,558.67
25	COMSTOCK	SERVICE INSTALLATION	286,100.22	132,423.68	19,863.72	112,559.96	173,540.26
29	COMSTOCK	TEMP POWER INSTALLATION	24,968.00	7,490.40	1,123.56	6,366.84	18,601.16
32	COMSTOCK.	ELECTRICAL POWER	1,473,585.00	0.00	0.00	0.00	1,473,585.00
ME175	CONTINENTAL CONV.	SCREW FEEDER	2,334.74	0.00	0.00	0.00	2,334.74
ME102	CONTINENTAL CONV.	LIVE BOTTOM BIN	5,596.10	0.00	0.00	0.00	5,596.10
127ME114	CONTINENTAL CONV.	LIVE BOTTOM BINS	75,978.56	33,775.00	0.00	33,775.00	42,203.56
120ME112	CONTINENTAL CONV.	SHAKING SCREENS	321,658.05	149,125.00	0.00	149,125.00	172,533.05
169ME129	CONTINENTAL CONV.	ROTARY VALVES	12,925.60	6,840.00	0.00	6,840.00	6,085.60
170ME132	CONTINENTAL CONV.	SLIDER BELT CONVEYORS	18,120.00	13,344.25	0.00	13,344.25	4,775.75
171ME160	CONTINENTAL CONV.	MODIFY PACKERS	62,648.50	0.00	0.00	0.00	62,648.50
104ME140	CONTINENTAL CONV.	ROTARY ORE DISTRIBUTOR	9,549.75	0.00	0.00	0.00	9,549.75
217ME143	CONTINENTAL CONV.	CYCLONE COLLECTORS	174,721.91	87,940.00	0.00	87,940.00	86,781.91
ME143	CONTINENTAL CONV.	HAND LEVER VALVE	68.35	0.00	0.00	0.00	68.35
3	DOMINION BRIDGE	STRUCTURAL STEEL	863,880.00	746,853.99	112,028.00	634,825.99	229,054.01
4	DOMINION BRIDGE	ROCK STORAGE BLDG	283,348.16	124,323.16	18,648.50	105,674.66	177,673.50
5	DOMINION BRIDGE	SERVICE ANNEX BUILDING	319,144.95	271,144.95	40,672.00	230,472.95	88,672.00
63	DOMINION BRIDGE		0.00	0.00	0.00	0.00	0.00
10	DOMINION BRIDGE	DUST HOPPERS & PLENUM	41,408.00	35,496.60	5,324.50	30,172.10	11,235.90

An example showing the Holdback and Payment Status report.

Source: SNC INC. (Project Management Services)

Figure 2.5

JUNE 30, 1976 EXHIBIT

MONTREAL QUEBEC NO. 0000 1

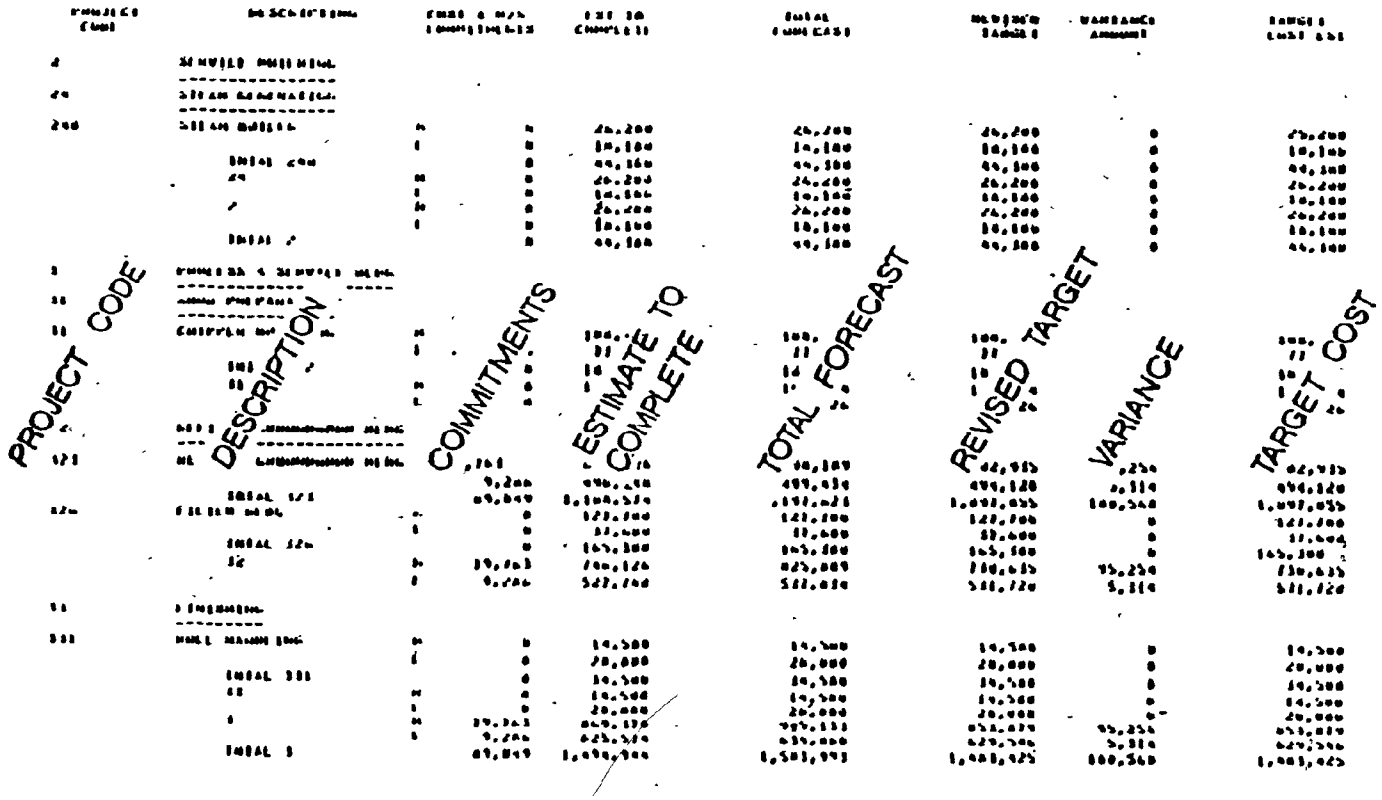
COST ITEM REPORT & FORECAST (IN DISCIPLINE ORDER)

PROJECT CODE	DESCRIPTION		COST & O/S COMMITMENTS	EST TO COMPLETE	--TOTAL FORECAST--		--REVISED TARGET--		VARIANCE AMOUNT	--TARGET COST--	
					HRS/MH	AMT	HRS/MH	AMT		HRS/MH	AMT
	M MATERIAL I INSTALLATION S SUB-CONTRACT E EQUIPMENT F LABOUR										
323-103	SOILS INVESTIGATION	M	23,070	1,070-		22,000		0	22,000		0
	****-103	M	23,070	1,070-		22,000		0	22,000		0
312-12	EXCAVATION & BACKFILL	M	0	0		0		0	0		0
	****-12	M	0	0		0		0	0		0
A 240	EXCAVATION	M		0	0CY	0	60CY	0	0	60CY	0
		L		794	128MH	794	128MH	794	0	128MH	794
B 21	EXCAVAT	M	0		69CY		69CY	0		69CY	0
		L	0		132MH		132MH	824		132MH	824
B-121	CHIP EXCAVATION	M	152		620C	0	620C	0		620CY	0
		L	1,021		372	418	372	2,418	0	372MH	2,418
			1.0	752- .011		0		0	0		0
						4,032		4,032	0	0	4,032
C 323-123	F.A GRADE-CHIP SIERRA		0	0	2430-	0	BF	0	0		0
			0	1,506	243MH	1,506	243MH	1,506	0		1,506
	****-123	M	0	0		0		0	0		0
		L	0	1,506	243	1,506	243	1,506	0	243	1,506
A 240-151	BACKFILL	M	0	120	30CY	120	30CY	120	0	30CY	120
		L	0	550	90MH	550	90MH	550	0	90MH	550
B 312-151	BACKFILL	M	0	303	91CY	303	91CY	303	0	91CY	303
		L	0	1,767	255MH	1,767	255MH	1,767	0	255MH	1,767
C 323-151	BACKFILL	M	0	0	100CY	0	100CY	0	0	100CY	0
		L	0	1,550	250MH	1,550	250MH	1,550	0	250MH	1,550
	****-151	M	0	423		423		423	0		423
		L	0	3,073	595	3,073	595	3,073	0	595	3,073

An example showing the general type of cost report for the use of general team members

Figure 2.6

COST REPORT & FORECAST (SUMMARY BY SUB-DIVISION)



An example showing a working tool for the cost controller (not for client.)

Sources: SNC INC.

Figure 2.7

FIELD LABOUR REPORT AUDIT LIST

B.B.M.C. SERVICES LTD PROJECT SUN OIL SARNIA PROJECT NO 3608

PROJ.CODE- SUBD. SUBJ.	--CODE-- DESCRIPTION	REPORTED TO-DATE %	THIS WEEK - QUANTITY	UM
210-455	WINDOWS		14	EA
457	DOORS		12	EA
459	SHELVES	32		LF
471	PAINTING	10		SF
610-601	PIPE 2IN. AND UNDER		200	LF
602	PIPE 2.5 TO 4 INCH.		100	LF
604	PIPE 6 INCHES		10	LF

PROJECT CODE
DESCRIPTION
REPORTED TO DATE %
QUANTITY THIS WEEK

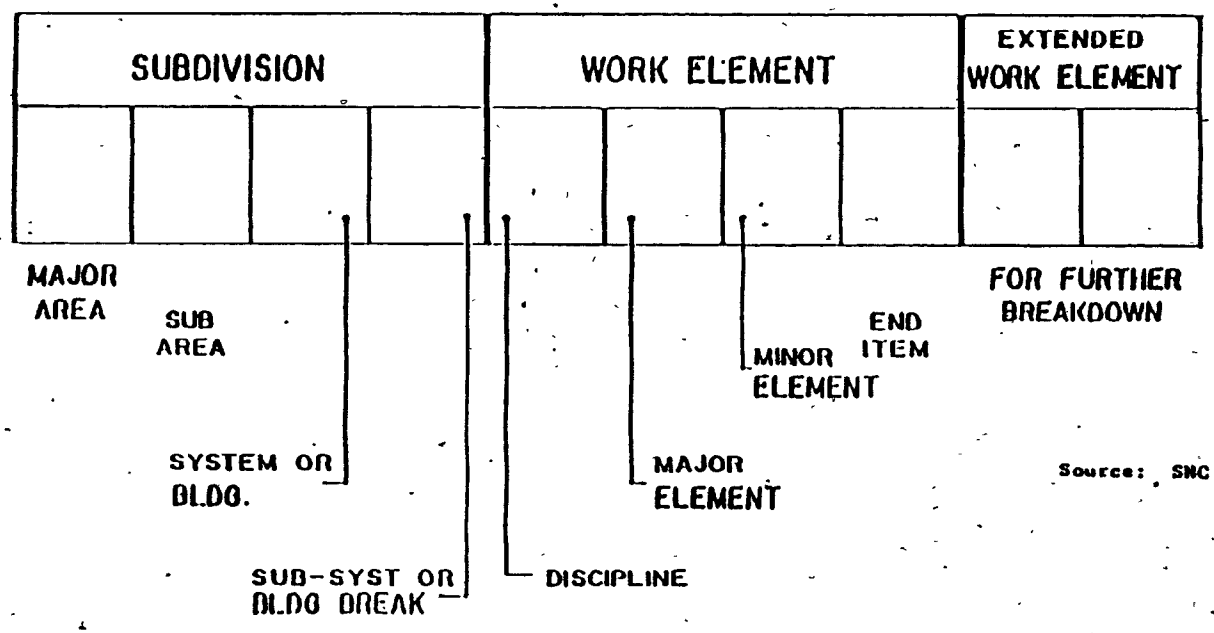
Source: SNC INC.

Figure 2.8

INTEGRATED CODING SYSTEM

CAPITAL COST CODING

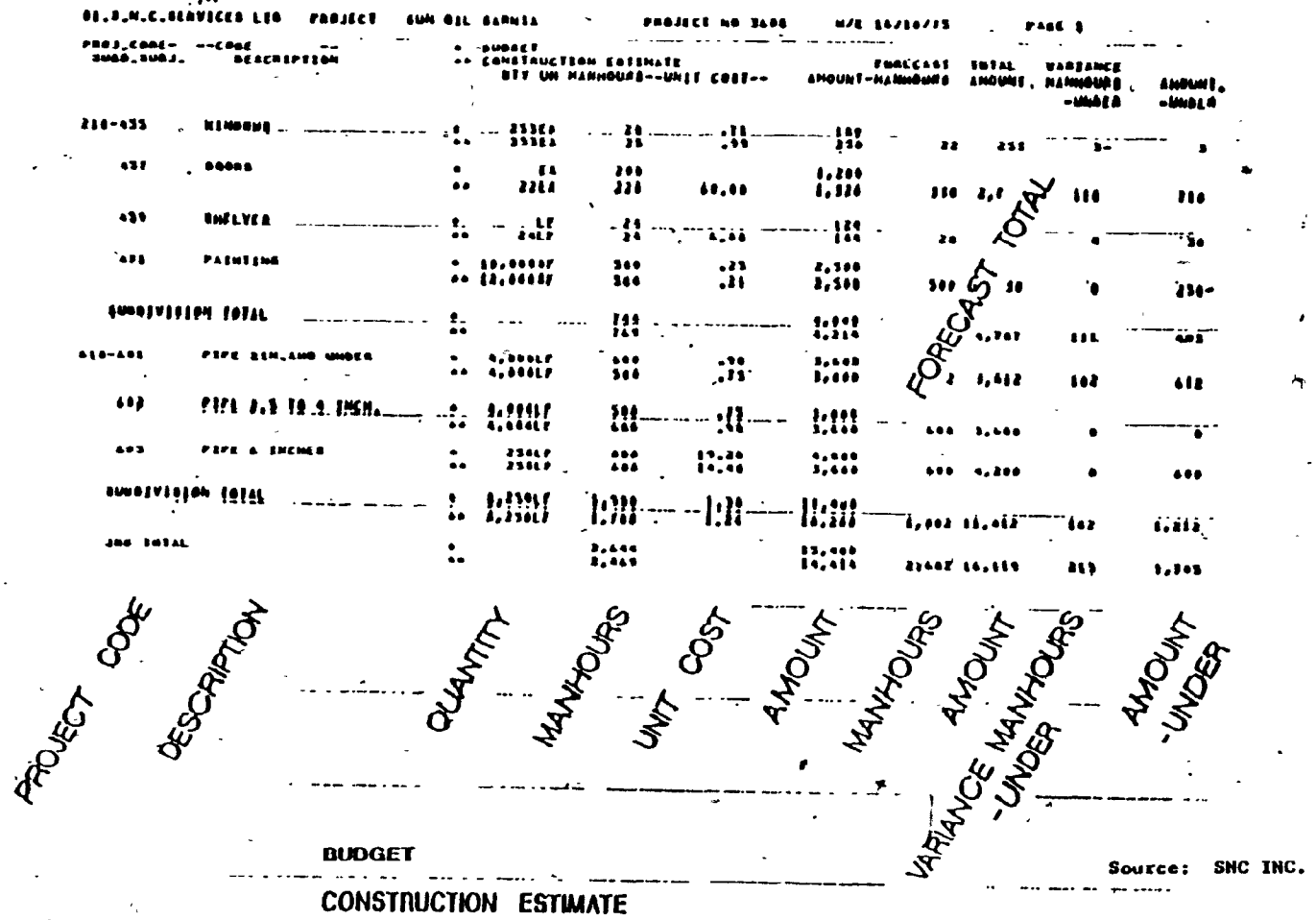
SAMPLE BLOCK CODING



Source: SNC INC.

Figure 2.9

SIMULATED FINAL COST FORECAST



PROJECT CODE
DESCRIPTION
QUANTITY
MANHOURS
UNIT COST
AMOUNT
MANHOURS
AMOUNT
VARIANCE MANHOURS -UNDER
AMOUNT -UNDER
BUDGET
CONSTRUCTION ESTIMATE
FORECAST TOTAL

Source: SNC INC.

2.16 Procurement

The Procurement function covers the purchase of equipment, preparation of contract packages, soliciting tenders, bid analysis, and the award of contracts for construction and installation work and for other services.

The Project Manager has the following responsibilities in the Procurement area:

- Reviewing and approving the procurement plan and organization with the Project Procurement Manager;
- Reviewing bid evaluations for major equipment and materials and subcontracts for these items to ensure that schedules and budgets are met;
- Obtaining approvals for procurement recommendations to client; and
- Reviewing and approving, with appropriate functional groups, requisitions for expediting and inspection.

Worldwide procurement for domestic and international projects demands an in-depth organization and the implementation of well-planned procedures. International projects are always complex and costly and, because procurement is an integral part of such projects, each of its functions is essential for successful completion.

International procurement is influenced by various factors that are different than in the U.S. and Canada, such as the following:

- Language barriers;

- Currency for payment (as currency fluctuates, the risk of loss increases);

- Import restrictions and duties (The Arab boycott, for example, or negative lists which identify items that cannot be imported, usually because they are available locally and the country wants to encourage local industry. High duties or penalties result from importing items on the negative list. Some developing countries have other complex export restrictions. For instance, Algeria requires a detailed list provided in advance of all items to be imported for a project during the year. Items not shown on the list are delayed or cannot be imported at all);

- Special taxes or tax credits--special taxes are enacted to encourage local commerce and discourage imports. On the other hand, tax credits are available if they might encourage business in a developing country (for instance, Brazil waives state and federal taxes on capital equipment when it is to be used to produce a product for export.);

- Codes and standards--an evaluation of the standards in the host country promotes an understanding of the local supply industry and results in improved procurement efforts;
- Market and supply services;
- Business conditions and customs;
- Laws;
- Code of ethics;
- Export shipping requirements; and
- Special financing requirements--financing may stem from client equity funds, an agency of the U.S. or Canadian government, a foreign government, or a combination of all three and each has different rules regarding procurement.

All of these factors plus the company's own directives are important when preparing a purchase order or a purchase contract for an international project.

The proper stipulation of shipping terms in the purchase-order/contract is especially important on overseas shipments because of the complexities of claims and insurance.

On overseas projects, expediting involvement continues after an order has been shipped from the supplier's plant. Expediting and traffic are closely coordinated to ensure that materials meet dockside or airport delivery requirements in order to be exported on schedule.

Field procurement operations on international projects can be very complicated because of customs and import requirements. A specialized knowledge of import licenses and customs clearances and declarations is required to accurately position the incoming goods.

Because foreign projects require local procurement as much as possible, procurement practices must be adapted to fit the capability of local industries.

Another important factor on international projects is warehousing. The volume of material and equipment required for an overseas project can be equal to the requirements of moving an army. All of the efforts in purchasing, expediting, scheduling, supplier quality, and shipping diminish in value and effectiveness if the warehousing operations at jobsite are not carefully planned. The people responsible for clearing the material from the shipper, transporting it to the warehouse, storing it, and performing inventory control are carefully selected.

2.17 Field Procurement and Material Control

The field procurement organization on a construction project is responsible for receiving, storing, protecting, and issuing construction materials at the jobsite and purchasing and subcontracting all field originated requisitions for material, equipment, or services.

Field procurement is the responsibility of the field procurement manager who operates under the line direction of the project construction manager (or superintendent) and receives functional direction from procurement department management.

Basic functions of field procurement at jobsite are:

- Field purchasing and subcontract support;
- Materials coordination;
- Jobsite material control;
- Equipment rental support; and
- Surplus disposal.

The jobsite procurement organization consists of the field procurement manager, several key personnel, and a clerical staff (with additional employees as required by the scope of the job).

On most direct hire projects, a field procurement manager (or supervisor) is assigned to the field staff. His primary responsibilities are:

- Formation and issuance of field originated subcontracts, up to a certain limit with the company's established procedures;
- Field purchasing;
- Vehicle and equipment rental;
- Jobsite material control; and
- Disposal of surplus material.

On small direct hire construction projects and on most contract management projects, a field procurement manager is not usually assigned. The field duties are assigned to other staff members.

Field buyers purchase or subcontract for all equipment and materials obtained directly by the jobsite organization in accordance with the procurement plan for the project. They obtain bids and issue purchase orders and subcontracts.

Material coordinators coordinate the requirements for and delivery of equipment and materials with jobsite field procurement, field engineering, planning and scheduling, superintendents, and with the division procurement forces.

2.18 Field Purchasing and Subcontract Support

Field buyers initiate purchasing and subcontracting by means of field material requisitions issued by project engineering and the project construction manager.

Subcontracts are issued for any procurement which entails the presence of the suppliers' manual labor on the jobsite. This includes rental of fully operated and maintained equipment. Bidding and subcontract services are provided by field procurement for field developed subcontracts. Major engineering subcontracts are developed by department or division procurement.

On international projects, buyers must have extensive knowledge of local practices, international traffic, local expediting methods, and currency exchange rates in order to get material to the project site.

2.19 Material Coordination

With changes occuring continuously in a construction schedule, the material coordinator maintains status records in field requirements for materials. He advises the procurement expeditor in the division office of material requirement schedules and assists in local expediting when requested.

Working with field engineering and the superintendents, he speeds the release of field material requirements to the field buyer. In addition, he coordinates the timely issuance of equipment and material to the construction forces.

On international projects, material coordinators and traffic and logistics personnel minimize potentially long delays in getting customs clearance by ensuring that all imports are properly covered by the required licenses and clearance documents.

2.20 Jobsite Material Control

Material control on the jobsite involves maintaining a flow of equipment and permanent and temporary materials to the construction forces to meet the requirements of the construction schedule.

Such control begins upon delivery to the jobsite and continues through warehousing and issuance to construction. It includes off loading and inspection for damage, quality, and specified quantity.

Upon satisfactory completion of receiving inspection activities, the material or equipment is released for storage or installation. Materials or items that are found not to be satisfactory are identified as non-conforming and are processed according to non-conformance procedures.

Inspected items are placed in laydown areas according to a plan which defines the proper environmental protection, security, and items identification and inventory procedures. Warehousing methods are standardized. Purchase orders require that serviceable packages be delivered (for example pallets are required when appropriate). For some projects, container unloading facilities may be required.

Items issued to construction are logged with the following information: Item, part number, date of issue, and recipient's identification. The handling and issuing of items at the jobsite are controlled by project tracking systems which record all transactions associated with individual equipment and material units from design definition through plant installation and start-up.

A formal traffic and logistics system is used to control transportation of materials to international jobsites.

2.21 Equipment Rental Support

The material supervisor is also responsible for jobsite administration of equipment rentals and tools supplied by the company. This includes notifying the equipment and tool department of the project's construction requirements. It also includes obtaining rental equipment, ensuring inspection of rentals upon delivery and at the termination of use, and making arrangements to ship to the next designated location.

Additional responsibilities include:

- Bid evaluation and issuing of the rental agreement for bare rental and fully operated and maintained equipment;
- Assisting in identifying qualified bidders;
- Assembling and issuing the bid package;
- Ensuring bid security and processing inquiries; and
- Reviewing the commercial aspects of recommended bidders.

2.22 Disposal of Surplus Material

Field procurement personnel are responsible for identifying and disposing of surplus material. A surplus listing is maintained throughout the construction phase and timely disposal is effected in client's best interest.

CHAPTER 3

3.0 Engineering

3.1 Objectives

Engineering is a vital part of the project management and consists of activities which are generally the same on any project regardless of its location. The objectives of this chapter are:

- To list some of the project engineering team's major responsibilities;
- To list some of the factors considered in the preparation of an Environmental Impact Report. This would be helpful for those who are involved with U.S. projects;
- To explain why land and habitat restoration are necessary;
- To explain some of the necessities and methods of protecting historical and archaeological aspects of the environment;
- To explain the importance of design criteria and how they are controlled during the design life of the project;

- To define the drawings and specifications and their respective roles on a project;

- To explain the documents generally used for monitoring the changes; and

- To explain why engineering design control is important.

3.2 The Engineering Team

The success of any consulting engineering firm depends largely on the production of the quality engineering and design documents as well as completion of work within schedule and budget.

In the early stages of the project, most likely during the business development phase, a project engineer is appointed by the division manager of engineering and some times with the client's approval. This person, typically a strong manager, sets in motion the mobilization of the engineering staff for the project. His prime responsibility is to assemble the team of the engineering group for his project from the disciplines within the engineering departments.

The project engineer reports to the manager of engineering as well as the project manager and is responsible for the performance of all engineering tasks in accordance with established quality standards, cost, and schedules. The project engineering team usually consists of a project engineer, one or two assistant project engineers, a quality engineer, and engineering planner, a cost engineer, and a group supervisor or lead for each of the engineering disciplines. The group supervisors are assigned a team of engineers, designers, and draftsmen.

The project engineering team is responsible for all engineering design work performed on the project. Special design support is furnished by specialty groups. The project engineer is responsible for the coordination of special design work conducted off the project to ensure the same degree of checking and control as work done on the project. The engineers assigned to the project are responsible for performing and completing the design effort in accordance with design criteria, codes and regulations, the schedule, and client requirements.

Any large project, regardless of its location, is supported by various engineering, planning, and control activities. As a result:

- Objectives are set and plans are made, understood, and accepted;
- The organization is formed and staffed;
- Construction facilities are established and introduced into engineering planning;
- The procurement department, in cooperation with construction management, ensures needed supplier information and timely delivery of equipment and materials;
- Costs and progress are controlled and reported; and

- Drawings are completed and specifications written for procurement and construction, as required.

On large international projects, engineering teams may be located in various offices and their efforts are coordinated and reviewed regularly.

If the project is in a remote location, temporary facilities to accommodate the crews and in some cases, training centers, have to be designed, built, and managed.

On domestic projects, Engineering's role is to support the project by writing the specifications required for procurement documents, preparing the detailed construction drawings on time, and keeping the engineering budget within limits.

On international projects, the consultant's role is modified because of the client's participation and the addition of training and transfer of technology. Distances, local conditions, and cultural barriers also add to the considerations influencing the project's success.

3.2.1 Project Engineering Team's Responsibilities

The basic responsibility of the project engineering group is to get the job done in the engineering phase of the project. Achievement of this objective entails:

- Prepare studies, analyses, preliminary engineering, estimates, and other data as required for the initial development of the project;

- Development of conceptual design of plant and layout proposals;

- Establishment of a schedule for completion of drawings, prepare calculations, drawings, and specifications which constitute the engineering design;

- Ensure that drawings, specifications, procedures, and instructions conform to project requirements, company standards, regulatory agency requirements, etc.;

- Assist the client in obtaining any necessary permits and licenses by furnishing required documentation;

- Prepare technical documents for procurement of equipment, material, labour, and services by contract, subcontract, or purchase order;

- Evaluate bids and make recommendations for awards;

- Review and approve drawings, technical data, manuals, and reports submitted by contractors, subcontractors, and suppliers;

- Evaluate proposed supplier and contractor/subcontractor quality assurance programs;

- Establish the needs for supplier surveillance/ inspection and audit, and review the results; and
- Prepare, review, and approve design changes, disposition of non-conformance reports, and purchase order revision.

3.3 Engineering Kick-Off

The first step in the engineering process is the engineering kick-off meeting which follows the project kick-off meeting. In the past, these meetings were held simultaneously. However, today there is a distinction between the two. Different people attend these meetings because their goals differ.

During the engineering kick-off meeting, which is attended by representatives of the various engineering disciplines (civil/structural, electrical, mechanical, plant design, etc.) and the client's representative, the client's expectations are determined, design criteria are established, responsibilities are clarified, and engineering priorities (milestones) are defined.

With the client, the engineering team establishes the client's engineering expectations and requirements. If some design work has been done by the client, it will be incorporated in the preliminary design criteria.

The client's requirements and expectations may also determine whether procurement does part or all of the purchasing.

3.4 Preliminary Site Studies

Site evaluation is one of the services provided by the engineering department. This service may include the evaluation of many sites in a wide area or only a few sites selected by the client. The total time involved for a site evaluation may take a year or longer depending on the scope of the study. During this period, each site is thoroughly evaluated by specialists in the fields of:

- Geology;
- Seismology;
- Soils;
- Hydrology;
- Meteorology;
- Environmental engineering; and
- Access.

All potential sites are examined from air, on foot or both. This initial evaluation usually eliminates many of the sites and indicates those requiring further evaluation. Additional visits and more intensive map or literature studies are conducted.

A comprehensive report is prepared and presented to the client for review and discussions about the selected site.

3.4.1 Traffic and Access

A survey is made of existing transportation facilities, material handling facilities, and capacities.

Access roads, highways, railroads, airports, waterways, and harbors are evaluated.

These surveys are performed at the beginning of the project because they directly influence the plant layout.

3.4.2 Geology and Seismology

On nuclear plants in particular (but also the construction of dams), geologic studies are conducted to evaluate site subsurface feasibility and seismicity.

A geologist usually visits the proposed site to view its general geological condition and a geologic map is made of the immediate area. From this map, a subsurface feasibility exploration is conducted including core drilling, geophysical surveys, and trench testing. Seismic activity and intensity are discussed with seismological consultants. A geologist supervises the contractor's work at site when the subsurface feasibility program is conducted.

3.4.3 Soil Studies

Soil evaluation studies include investigation and inspection of site soils, evaluation of proposed foundation systems, estimation of settlements, and determination of soil parameters necessary for the structural design of the facility foundation. The final phase of soil studies include recommendations on the earthwork phase of construction and preparation of tests, tables, and figures. Drilling determines conditions beneath major structures.

3.4.4 Environmental Services

On major projects, the project engineer is responsible for environmental services to the client. In this case, the project engineer requests the research and engineering department to provide this service.

As part of its comprehensive architectural, engineering, and construction services to industry, government, and business, engineering firms provide:

- A practical understanding of environmental changes that can accompany facility construction and operation;
- An up-to-date knowledge of environmental regulations and licensing requirements and procedures for the design of environmental study programs and pollution control equipment;
- Direct access to engineers, designers, and construction personnel for planning and implementing effective mitigation measures from conceptual design and site study to actual operation;

- Project experience in state of the art pollution control technology for air, water, and solid waste management; and

- Evaluation of:

  - Energy related facilities such as pipelines, refineries, nuclear waste depositories, LNG projects, and fossil, nuclear, and hydro-electric power plants;

  - Mining and ore processing facilities;

  - Transit related projects such as airports and rapid transit systems; and

  - Water related facilities such as dams, irrigation facilities, ports, navigation facilities, and regional waste water system.

Recognized environmental consultants or subcontractors, often located near the project site, are selected for support when necessary.

3.4.5 Environmental Consulting Services

Environmental assessment is provided by the environmental division of the consulting engineering firm and becomes a very important activity on any major industrial type project.

Working in such diverse areas as air and water quality, ecology, sociology and urban planning, archaeology, economics, and noise, assessment teams prepare reports required under state and federal guidelines for funding and permits.

The following factors are considered for a typical environmental analysis:

- Land features including topography, geology, seismology, and soils;
- Land use;
- Air and water quality and related aspects such as meteorology and hydrology;
- Noise levels;
- Ecological factors including terrestial and aquatic features, revegetation and wildlife habitat preservation and restoration;
- Economic, social, and cultural factors including demography, projected growth rates, and demands for new infrastructure;
- Regional and urban economics;

- Historical, archeological, and other factors with cultural or aesthetic significance; and

- Project design alternatives.

The emphasis given each item depends on the location and nature of the project.

3.4.6 Site Studies

In the early steps of project implementation, identification of an appropriate site which meets engineering, socioeconomic, and environmental criteria is an important part of environmental assessment.

In the course of determining the best site for a project, much of the potential environmental impact of that project can be identified and appropriate mitigation measures can be incorporated during the project design stage. Site screening can reduce the potential for adverse effects by selecting areas to minimum environmental sensitivity.

During the site selection process, environmental activities include:

- An inventory of available data for each region, area, or site;

- A preliminary determination of the environmental sensitivity of each site;

- An analysis of the potential environmental impact on each site resulting from construction and operation; and

- A determination of the optimum site from the standpoint of technical and economic feasibility.

Besides identifying promising project locations, this process leads to recommendations for alternative sites and designs.

The reports resulting from these activities can be used as a major portion of the "Alternatives including proposed action".

Technical specialists work closely with the project engineering staff on detailed site screening and selection studies. They contact responsible agencies, conduct data searches and site surveys, and perform analyses to ascertain whether potential sites meet environmental, engineering, and socioeconomic criteria.

3.4.7 Base Line Surveys

To identify the impact of a proposed project, it is necessary to provide an environmental inventory of the existing area.

This inventory includes a coordinated literature search, and field and laboratory programs. Data surveys are conducted using in-house libraries (historical data) and data search capabilities in the areas of air quality and meteorology, noise, socioeconomics, archaeology, and ecology.

Draft environmental impact reports or statements are required as a part of the public review process under several state and federal guidelines.

These reports are prepared as specified by the lead agency and in a language suitable for review by a layman without sacrificing technical accuracy. Environmental documents are prepared for project sponsors. They describe the proposed project and alternatives, the environmental setting of the project, and the impact expected if the project is implemented.

Factors considered in the preparation of an Environmental Impact Report (EIR) fall into the following categories:

- Physical and chemical characteristics such as water quality (ocean, river, lakes), flow and sedimentation, and the natural shoreline;

- Biological characteristics including plankton, commercial fisheries, wetlands, waterfowl, terrestial animals and plants, and rare or unique species;

- Cultural and social factors including land use consistency, recreational value, demographic stability, wilderness and open space qualities, historical, archaeological and educational value, and resource consumption; and

- Other concerns such as air quality and noise.

See reference No. 6.

3.4.8 Special Studies

A wide range of special studies may be required as a project develops.

Some of these are designed to answer specific questions from the client and environmental specialists devote their talents to finding and implementing practical and effective solutions. Types of client questions examined in recent studies include:

- How can waterfowl be prevented from landing on toxic industrial waste water ponds?;
- How can biofouling of a cooling system for an industrial facility in the tropics be prevented while, at the same time protecting nearshore fisheries vital to the local economy?; and
- How can environmental specifications be enforced?

The problems are defined, solutions, and alternatives are proposed and assistance rendered in implementing the chosen program. The progress of the program is monitored in order to incorporate any modifications or refinements.

3.4.9 Agency Review and Public Meetings

Environmental impact reports must be reviewed by governmental agencies and the general public. A consulting engineering firm's own staff usually have the experience in handling the public workshops where details of the planned project are discussed and public interest areas identified. It is also normal for an EPC firm to work closely with technical advisory committees composed of agency representatives, local scientists, and other persons interested in the environmental assessment effort.

When feasibility studies, conceptual plans, or impact reports are presented to the public, specialists provide expert testimony and support during public hearings and assist the project sponsor and lead agency in responding to comments and questions.

3.4.10 Environmental Monitoring

Environmental monitoring of the construction and operation of a facility is a growing requirement of regulatory agencies at all government levels and is necessary to support a wide range of activities such as obtaining construction permits and operating licences and complying with legal stipulations.

The increase in monitoring requirements is a consequence of several factors:

- The increase public demand for environmental quality;
- The lack of suitable sites for new industrial facilities; and
- The general growth of government regulatory agencies.

These agencies are requiring evidence that mitigation measures proposed in environmental reports and permits stipulations are being applied effectively.

- An effective environmental monitoring program helps ensure uninterrupted construction activities, helps avert conflict with local communities and minimizes the chances of future legal action. Environmental monitoring is best accomplished with a comprehensive program that includes identification of legal obligations, covering of necessary information to subcontractors, training of monitoring personnel, procurement of instrumentation, review of field monitoring reports, coordination with regulatory personnel, and continued updating to keep pace with new environmental requirements.

3.4.11 Air Quality

Under the clean air act, a prevention of significant deterioration analysis must be prepared for all prospective facilities in the U.S. that have the potential to emit a specified quantity of pollutants into the atmosphere. Many States have additional and more stringent air quality requirements.

The prevention of significant deterioration (PSD) analysis requires a minimum of one year of constant monitoring of base line air quality.

In order to adhere to clean air act requirements, meteorological and climatological studies are prepared to describe the weather phenomena of a particular plant site. These studies are used to develop plant design criteria based on factors such as precipitations and wind loading in order to develop the site layout of cooling facilities, etc.

For projects in regions having severe weather conditions such as the Middle East or far north, climatological summaries may be integral planning tools around which the complete project may be structured.

These studies usually involve site visits by a meteorologist to assess the local wind flow and climatic characteristics and to locate available weather records. Site specific phenomena are used to determine whether atmospheric emmissions will lead to violations of air quality criteria, result in hazardous conditions, or affect operation of the plant.

Environmental reports require assessment of the effects of heat dissipation, gaseous effluents, and atmospheric chemical discharges during operation.

Evaluations of fogging and icing from cooling ponds or towers, deposition of salts from cooling tower drifts and discharge of impurities into the air are conducted by air quality specialists.

3.4.12 Water Quality

The Clean Water Act stipulates that all point source fluid discharges from an industrial facility be continually monitored. The National Pollution Discharge Elimination System (NPDES) requires monitoring of all toxic chemicals, thermal emmissions, and "gray area pollutants" (virtually all other emissions) into all water systems.

The results of this monitoring must be compared with a minimum of one year of base line water quality monitoring. Like air quality monitoring, the procedures for adequate water quality monitoring are strictly controlled by the Environmental Protection agency (EPA) and are frequently revised.

Water quality monitoring is important during preconstruction (for ambient data) and during the construction and operation phases of any facility discharging into any water body.

The increase of phosphate or other nutrient levels in an existing water system is of particular concern to the regulatory agencies because this increase often affects birds, mammals, and aquatic life.

3.4.13 Environmental Noise

At present, no federal regulations exist governing acceptable noise levels at property lines or in nearby communities. The EPA, however, has published recommended community noise criteria and a draft of a community noise ordinance. The U.S. Department of Housing and Urban Development (HUD) has also recommended acceptable community noise levels. Regulatory agencies at all government levels refer to these EPA and HUD criteria.

To comply with these criteria and recommendations, studies are conducted in:

- Noise evaluation for environmental reports;
- Environmental noise prediction and control;
- Occupational noise exposure measurement and evaluation;

- Community and construction noise prediction and control; and

- Airport noise.

3.4.14 Revegetation--Land and Habitat Restoration

Industrial projects such as mining, oil shale facilities, or pipelines can severly disrupt existing vegetation and the wildlife that it supports. Displaced wildlife will attempt to re-establish in outlying areas not affected by the project. This may stimulate population imbalance and instability in the wildlife populations already resident to those areas. Particular attention is paid to habitat disruptions which may affect rare or endangered species and migratory species because these are generally more sensitive to habitat change.

The operation impact is usually associated with environmental contaminants released by the new facility, physical impairment of migratory patterns, etc. Air emissions can severely affect vegetative productivity and can be toxic to wildlife.

Certain airborne chemicals accumulate in plant tissues; this can affect wildlife dependent upon the affected vegetation.

Migratory patterns of wildlife can be disrupted by physical barriers such as fences, fill or spoil areas, roads, or transmission corridors.

Most States in the U.S. have adopted reclamation acts requiring that an effective program for reconstituting the land be established before the regulatory agency approves a construction permit. A successful revegetation program minimizes soil erosion and siltation of waterways while providing aesthetic, economic, and ecological benefits.

Agronomists design methods to restore vegetation and land productivity by recommending soil amendments, mulches, and specific fertilizers. They work closely with construction specialists and/or mining engineers to develop appropriate grading specifications and slope requirements. Methods are designed for using wastewater from municipal and industrial sources for irrigation.

3.5 Economic and Social Planning and Assessment

The construction and operation of large industrial facilities invariably impact (directly or indirectly) social, cultural, and economic characteristics of the human environment.

Some of the effects last only during construction activities, while others continue throughout the operating life of the project. In addition, these impacts and those affecting the physical and biological setting can generate second order effects on the social setting such as wage inflation and increasing demands for housing, schools, utilities and food, police, and other community services.

Socioeconomic impact assessments include the following elements:

- Base line analyses of social and economic structures in the vicinity of the project including housing, facilities, services, and infrastructure capacities; and
- Determination of project manpower characteristics such as total manpower demand, supply and sources, wages, portion of work force relocating, etc.

3.6 History and Archaeology

Because historical and archaeological aspects of the environment such as sites, landmarks, or objects of antiquity are non-renewable resources, positive protective measures have been initiated by various federal, state, and local agencies. The location, identification, and protection of such cultural resources constitute a significant part of an Environmental Impact Report (EIR).

Determination of the location, identity, and significance of these resources may include:

- A survey of all pertinent published and unpublished literature and site reports to determine the existence of known sites in the project area. This may consist of spot checking potentially significant areas based on a knowledge of local prehistoric settlement patterns or statistical sampling; and
- An intensive preliminary field reconnaissance involving a complete visual survey of the project area and its immediate vicinity.

In dealing with non-renewable historical and archaeological resources, mitigating measures include two major options:

- Preservation--where sites are preserved, measures must be taken to ensure their protection from public vandalism. Protection may include making the site a national monument thereby placing it in protective custody or camouflaging the site from public view. It is important in the latter case the EIR's do not disclose the exact location of the site; and

- Salvage--where site preservation is not feasible, salvage operations are necessary whereby excavations are made by archaeologists to recover and preserve as much data as possible.

3.7 Overseas Environmental Services

Foreign governments are also concerned with overseas environmental regulatory efforts, primarily in response to the needs of international lending organizations, regulatory agencies, international protocol/conventions, and governmental entities which, in many cases, now require an environmental review of development projects.

Through support provided by the Consultant's overseas offices, a current file of international environmental requirements is maintained for such organizations as the World Bank, the Agency for International Development, and the Export/Import Bank as well as for provincial and national regulatory agencies.

As a result of this file of applicable regulations and established criteria, companies can quickly respond to requests for environmental planning, biological and social assessments, and/or monitoring of potential effects of development projects.

EPC companies are currently working with international regulatory organizations and governmental entities to prepare predesign environmental planning reports, environmental impact assessment reports, and postoperational air and water quality monitoring specification documents. In addition, the company develops site criteria for projects in countries that have not yet developed national criteria but are aware of the potential long-term environmental consequences of development projects.

3.8 Design Criteria

Design criteria are those standards, codes, regulations, and/or other information, including client requirements, which are used as a basis for the design.

Project specialists, under the direction of the project engineer, prepare, revise, and document design criteria in accordance with established procedures. The following are considered during preparation of design criteria.

- Client requirements and standard practices;

- Government and industry design codes and regulations;

- Design consultants own technical data and design guides;

- Vendor/supplier criteria; and

- Site conditions.

Documents such as the project Environmental Report, the Preliminary Safety Analysis Report, and others containing design criteria should be compatible with the project design criteria document and should be kept current.

Design criteria are documented and controlled throughout the design phase of the project. Design criteria prepared by a discipline are reviewed by the group supervisors of all other disciplines for compatibility with their established criteria. The project engineer approves the design criteria documents developed by each discipline group supervisor.

After review and approval within Home Office, the design criteria are forwarded to the client for review and acceptance.

Revised design criteria are reviewed and approved in the same manner as the initial criteria and the project engineer is responsible for ensuring that the revised criteria are incorporated in the design.

3.9 Drawings

Drawings that may be encountered on a project can be classified as following:

- Engineering sketches--as the name implies, engineering sketches are informal drawings which may be prepared during the design process as a means of working out details or arrangements, locations, interfaces, etc. Engineering sketches do not necessarily reflect final design. They are not used for fabrication or construction and are normally closely controlled within project engineering;

- Preliminary design drawings/process flow diagrams and piping and instrument diagrams (P & ID's)--as the design evolves, engineering prepares process flow diagrams and P & ID's. These are documents from which preliminary drawings are prepared and on which cost estimates can be based, project schedules developed, contracts/subcontracts negotiated, and material/equipment bids solicited. Preliminary design drawings are not used for fabrication or construction;

- Final design drawings--although drawings may be revised as the project progresses, final design drawings are used for fabrication/construction and procurement of materials, equipment, and subcontracted services.

Isometric drawings show the final routing of the piping system. The supplier develops his own shop spool drawings from the isometric drawings;

- Vendor drawings--suppliers and subcontractors may be required to design equipment to satisfy the terms of the procurement documents. Vendor drawings are submitted for review and acceptance and may be required for installation; and

- Field sketches--field sketches are based on final design documents. These drawings interpret the design in terms of construction methods, plans, techniques, etc. Field sketches do not establish or alter design concepts, but translate design drawings into working plans and diagrams for use by the construction trades and craftsmen.

3.10 Drawing Change Notice (DCN)

DCN's are initiated by construction personnel to request a change in approved engineering drawings and specifications.

When a DCN is received by a group supervisor, it is assigned to the responsible engineer for action. He either approves the DCN and initiates the necessary revisions or disapproves it. He then forwards his decision to the project engineer for his approval.

3.11 Field Change Notice (FCN)

FCN's are initiated by construction personnel to advise the project of minor changes made at the jobsite which do not deviate from the requirements of the technical specifications.

3.12 Revisions to Drawings

Revisions to drawings are processed in the same manner as the original drawings. A revision note is made on the drawing which includes a statement of the purchase of the issue and a description of the changes made.

3.13 Specifications

Specifications communicate requirements and standards for materials, parts, components, equipment, workmanship, methods, and procedures. Like a material list or a parts list, specifications may deal only with the end result or product. On the other hand, specifications may define detailed instructions for performing certain tasks or operations in the fabrication/installation process or they may establish requirements for written procedures, verification methods, or records. Also, specifications define the codes and standards applicable to the work.

Standard specifications are used when available. Specifications not available as a standard may be prepared by project design engineers or off-project personnel (staff, specialist groups, or service agencies) as assigned by the group supervisor and with the concurrence of the project engineer or chief engineer.

In preparing specifications, the following are considered:

- Project design criteria;
- Codes, standards, and regulatory requirements, where applicable;
- Quality standards and acceptance criteria;
- Design analyses (materials, stress, etc.);
- Design or operational test requirements;
- Requirements for packaging, handling, shipping, and storage;
- Engineering required hold points including drawing approvals; and
- Requirements for code certificates, material test reports, and performance test reports.

All engineering specifications are checked by a qualified engineer other than the originator. Specifications are checked against the design criteria documents to ensure that they conform with specified configurations and materials.

All design specifications are reviewed by the group supervisor and approved by the project engineer.

3.14 Project Material Requisitions

The engineering department is also responsible for the preparation of the engineering documents for the procurement department and transmitting those documents to this department in a manner standardized by the EPC firm and some of these documents are described in the following:

- Purchasing memorandum, prepared by the responsible design group, which transmits Engineering's instructions to Procurement requesting one or more of the following:
  - Request for bids (with a proposed list of bidders).
  - Preparation of a purchase order or contract.
  - Preparation of a purchase order revision or contract change order;

- material requisition which gives procurement information regarding the material, equipment, or services to be purchased. It also serves as an information document for the client, bidder or seller, field office, surveillance/inspection, accounting, expediting, traffic, and receiving;

- Technical or design specifications which provide the specific technical requirements of the equipment, material, or services involved. They may cover such items as electric motor requirements, seismic design specifications, quality assurance program requirements for suppliers, and welding and non-destructive test (NDT) requirements;

- Drawings--in describing the item to be purchased or the work to be performed, the material requisition should contain project design drawings, revisions, and data sheets that are properly referenced, numbered, and titled; and

- Form of proposal is an attachment to the bid package on which the bidders can fill in detailed information on prices of equipment and/or services (such as cost of each unit), freight, spare parts, shipping point, and delivery times.

3.15 Engineering Design Control

If the design does not reflect the requirements defined by the contract, the completed facility built to that design will not be a quality job. Engineering design control defines criteria and quality level and the applicable codes and standards, industry criteria, and established professional standards.

For each stage of design work (conceptual, preliminary/interim, final, and fabrication/construction design), there are built-in checks, independent reviews, alternate checks, and tests of design concepts. Drawings are checked and reviewed for correctness, completeness, and conformance to design criteria, legibility of microfilm copies, drawing number format, etc. The discipline group supervisor is responsible for assigning competent checkers. Design guides or standard manuals provide appropriate check lists that may be used in reviewing and checking drawings.

Often, scale models of the more complex projects are used to test design concepts or verify configuration; they may also be used by construction in conjunction with design drawings. On projects where models are used, plant design personnel are responsible for coordinating activities affecting the model including equipment arrangement, structural arrangement, and tagging.

The model shop is responsible for model component-making and model base assembly.

The end result of engineering is not a product in the usual sense. It is relatively simple to inspect and test products such as appliances or cars. This is not the case with a software product such as a design document. The testing is accomplished by means of an independent review/check by competent design personnel and by testing design concepts against criteria.

At the same time, controlling the preparation, distribution, and use of design drawings and specifications is fundamental to an effective design control system. Design documents establish the requirements to be met, therefore, they must be clearly understood, controlled, and readily available for use.

3.16 Quality Engineering

Quality engineering ensures that the requirements of the design are met by the design. It is and should be a regular part of all design work.

Inadequate design, errors in design documents, or design concepts that have not been fully tested can be costly and may have serious consequences. There are numerous instances where litigation has resulted from design deficiencies or errors.

3.17 Historical Report

After the project is completed, an historical report is issued. The project engineer has the responsibility for the preparation and distribution of the engineering portion of the report.

Required data for the report are compiled under the supervision of unit engineers and group supervisors prior to departure from the project.

Engineering historical reports are used by engineering managers, project engineers, and design groups in estimating manhours, costs, forecasts, and in evaluating schedules and performance. Therefore, a detailed and accurate report is of utmost importance.

CHAPTER 4

4.0 Construction

4.1 Objectives

The objectives of this chapter are as follows:

- To describe some of the construction department's activities during the initial phases of a project;
- To describe the various elements necessary in the evaluation of a construction project;
- To discuss/describe several activities that are part of a project; and
- To explain quality assurance and how it works.

4.2 Organization of the Construction Project

The project office and field organization vary to some degree upon type and size of the project, the EPC company's own policy, type of engineering/construction contract, physical location, availability of craftsmen, and other factors. However, the field organization is generally structured in the following manner.

4.2.1 Project Construction Manager

The division manager of construction or an equivalent authority of the company designates a project construction manager to maintain functional contact with the field construction manager. The project construction manager is responsible for the following duties:

- Evaluating and reviewing the performance of the field construction manager with the manager of construction;
- Reviewing, evaluating, and approving personnel action for field non-manual personnel;
- Assisting the field construction manager in the selection of non-manual positions;

- Keeping the lines of communication open, between field and division management concerning general, technical, and related matters;

- Visiting the jobsite routinely and responding to the site problems which need his attention; and

- Preparing certain division reports, based on information received from site.

4.2.2 Field Construction Manager

The field construction manager is responsible for the field project operations. He is responsible for coordination, guidance, and motivation of the field staff in order to construct the facility, within cost, on schedule, to the client's satisfaction, and in accordance with the plans and specifications.

The field construction manager reports to the project manager concerning day-to-day project field operation. He is usually the first of the field staff to be assigned to a project. With a project manager, he is responsible for developing a field staff organization and securing personnel for the project. His functions are as follows:

- Organizing and supervising the non-manual staff;

- Directing overall field operations;

- Monitoring quality, costs, schedules, and progress of the work;

- Site trouble shooting;

- Approvals of field change orders;

- Liaison with clients; and

- Coordination among the contractors.

4.2.3 General Superintendent

The position of general superintendent exists usually on a direct hire project.

The general superintendent is responsible for the performance of jobsite construction activities. He reports to the field construction manager. He usually performs directly or delegates to subordinates the following duties:

- Supervising and coordinating all activities of all parties working in the field;

- Planning and executing work to keep costs within budget and schedules. This includes selecting, purchasing, monitoring, construction equipment and materials, etc;

- Maintaining smooth working relations between subcontractors and initiating backcharges for work performed by subcontractors;

- Developing and implementing work safety rules;

- Maintaining jobsite security; and

- Working closely with labour relations representatives, with union representatives, and resolving associated craftsmen related problems.

4.2.4 Area Superintendent

The area superintendent usually reports to the general superintendent or field superintendent. He supervises field construction activities in a specific area or for a specific craft. These include organizing work activities, determining work methods, scheduling all construction work for his craft, controlling field costs, ensuring conformance with drawings and specifications, maintaining quality of construction, and assigning work to craft foremen.

4.2.5 General Foremen

General foremen are usually responsible for maintaining schedule and for planning the activities for the trade work force. He uses established budgets and schedules as a planning resource.

He coordinates his activities with the craft superintendents and with various foremen regarding their equipment and schedule needs. He reports to the discipline superintendent.

4.2.6 Lead Field Engineer

The lead field engineer, sometimes called the resident engineer and sometimes the project engineer (some jobs have both), is responsible to the field construction manager for all technical and administrative functions of field engineering group; he coordinates his efforts with division engineering and the field inspectors.

His functions include interpreting contract drawings and specifications, preparing supplemental drawings and specifications, assisting superintendents plan work methods, checking quantities of materials and equipment, checking to ensure that construction conforms to drawings and specifications, checking that workmanship is satisfactory, providing surveying controls, assigning work to field engineers and surveyors, and recording field activities. He coordinates and approves all field changes.

4.2.7 Field Engineer

A field engineer performs all field engineering activities in a specific area or engineering discipline. These include interpreting contract drawings and specifications, preparing supplemental drawings and specifications, assisting superintendents to plan work methods, checking quantities of materials and equipment, requisitioning additional materials and equipment, checking to ensure that construction conforms to drawings and specifications, checking that workmanship is satisfactory, assigning work to field inspectors and recording field activities.

The initial field change requests for modifications to the project scope. They report to the lead field engineer.

4.2.8 Field Cost and Schedule Supervisor

The field cost and schedule supervisor organizes and administers all field cost control and scheduling work and supervises the work of field cost engineer and field planning and scheduling engineer. He reports to the project superintendent.

4.2.9 Field Planning and Scheduling Engineer

The field planning and scheduling engineer supervises all field scheduling activities including interpreting and expanding the detailed construction schedules, preparing schedules for field work, recording and reporting actual field progress, and providing field input for necessary project schedule changes. He reports to the field cost and schedule supervisor.

4.2.10 Project Field Quality Engineer

The project field quality control engineer administers the field quality control program.

This includes organizing the quality control work, preparing special project control procedures, monitoring field inspection and documentation performed by others, preparing non-compliance reports, and assembling project quality control records. He reports to the project superintendent.

4.2.11 Field Safety Engineer

The field safety engineer supervises all project field activities concerned with accident, fire and theft prevention, and protection including first aid treatment, fire fighting, security, and emergency evacuation of the site. He reports to the project superintendent.

4.2.12 Field Contract Administrator

The field contract administrator administers all work performed by subcontracts; organizing subcontract administration work; interpreting drawings and specifications; approving subcontractor's work methods and scheduling their work; and controlling costs. Inspecting construction to ensure conformance with drawings, specifications, and workmanship; reporting subcontractor activities and authorizing payment.

If changes to the project scope are necessary, he requests action by the project field engineer. He reports to the project superintendent.

4.2.13 Resident Field Engineer

The resident field engineer is the field representative directly associated with the work of contractors. He reviews, monitors, supervises, inspects, and approves the construction work performed by contractors. He reports to the field construction manager. His major functions are:

- Managing contractor field activities through supervision of field engineers and inspectors;
- Monitoring progress, costs, and schedules;
- Coordinating the work of contractors;
- Supervising testing; and
- Performing contract administration functions in the absence of a permanent contract administrator for supervisor.

4.2.14 Project Accounting Manager

On all direct and major contract management projects, a project accounting manager is assigned to the field staff by the division controller.

On small construction management projects, the field duties of the project accounting manager are distributed among other staff members and accounting personnel.

Major functions performed by the project accounting manager are:

- Supervising office clerical staff;
- Supervising timekeeping;
- Maintaining the general ledger;
- Preparing financial statements;
- Preparing payroll;
- Maintaining cost and commitment ledgers;
- Supervising petty cash funds; and
- Ensuring that required business licenses and permits are obtained.

4.3 Evaluation of the Construction Project

Every construction project, regardless of its size and geographical location, passes through certain steps, which include the organization, evaluation of the construction site, site planning, procurement, and estimating.

Since we have already described a standard organization which is required as a minimum on any industrial type project by a construction management firm, I am not going to mention here the organization of a contractor, instead I will discuss in following the elements of evaluation of a project when it is being looked upon for the construction purpose.

4.3.1 Mobilization

The mobilization usually takes place after a contract has been signed. The advance party in the mobilization consists of the construction manager, job superintendent, and other key personnel, which may be essential at that time. The advance party inspects the site to check on the location of the proposed facility, access roads, and temporary facilities. In some cases, the availability of the residential facility for the construction crew may also be investigated.

4.3.2 Ground Breaking--Civil Work

The following major activities are the responsibility of the civil services group and are planned prior to start of the primary facility:

- Survey and site preparation, foundation, excavation, and backfill;
- Utilities;
- Railroads; and
- Waste water ponds, cooling water systems..

4.3.3 Site Preparation

In the beginning of a project, a site plot plan is developed. An excavation plan is developed, grades are determined, and drainage systems are laid out.

Location drawings are made for the plant facilities, taking into consideration the location of the structures to each other, construction requirements, site geometry, topography, and meteorology access. Details of the design are based on accurate survey and soil exploration data obtained during site selection.

Grades are established for balanced earth work with emphasis on minimizing adverse environmental impact.

Early in the site selection stage, a qualitative prediction of soil stability is made along with a preliminary estimate of its ability to support the proposed facilities.

When the site is selected, a soil investigation program is started. A thorough review of existing information concerning site soils is made, subcontracts are prepared for investigation work, inspection of drilling operation, and testing of samples obtained from boring. Drilling determines conditions beneath major structures.

Foundation requirements are determined and decisions are made on the structural foundation system for each facility.

4.3.4 Utilities

The development and availability of the utilities are essential for site preparation.

Drawings showing the utilities are prepared and are coordinated with other disciplines, ducts location for electrical cables, sewer lines and sewage treatment plant are chosen, and proper drawings and specifications are prepared.

4.3.5 Access Roads

Alignment and details of plant access roads are established along with the location, size, and orientation of permanent parking lots.

Drawings are prepared to show road plans with special consideration being given to the intersection of the plant access road and the main thoroughfare. Preliminary access road plans are developed to support site development. When the plot plan is approved and final road plans developed, the initial designs are refined and finalized.

The location of fences and gates is determined early in the design phase so that a permanent security fence can be erected prior to construction.

4.3.6 Temporary Facilities

During the preliminary engineering phase and before excavation starts, the Construction Department assists construction management in developing temporary construction facilities. These facilities are laid out and designed in conjunction with the layout of permanent plant facilities and include:

- Office, warehouse, maintenance shop, welding test shop, electrical and pipe shop, guard shack, change house, first aid station, and parking lots;
- Laydown areas and storage locations; and
- Underground utilities including electrical conduit and gas, water (potable and fire protection), air, oxygen, and drainage systems.

In conjunction with the field administration manager, compatible communications facilities are determined. These include:

- Telephone equipment (this necessitates agreement with the jobsite telephone company and is normally handled by a client representative and the construction coordinator);

- Teletype and telecopier facilities;

- Data processing via telephone (terminals) or a back-up system; and

- Tie lines to the head offices.

The types of systems chosen (WATS, switchboard control, direct dial) are based on their projected use. In addition, jobsite communication systems are developed including telephones, radios, intercommunication systems, and public address systems.

In most cases, drawings and specifications for the development of the temporary construction facilities are standard items.

Drawings and specifications are provided to subcontractors who may furnish and erect such items as:

- Water storage tanks (if required);

- Structural steel buildings;

- Foundations and floor slabs;

- Heating, ventilating, and air conditioning (HVAC) equipment;

- Electrical work; and

- Plumbing and piping systems.

Temporary roads and railroads are designed and laid out if required; existing roads are checked for adequacy.

Trailers which can be used for temporary offices are often rented from a contractor. According to the agreement, they may be:

- Returned to the contractor;

- Dismantled; or

- Left on the site for later use by the client.

4.4 Job Closeout--Demobilization

4.4.1 Turnover

Turnover is the point where ownership is transferred, if the project has been procured and constructed type turn key, or where it has been a management project for the firm.

Turnover generally occurs prior to the completion of activities such as painting, landscaping, general site cleanup, disposal of surplus materials, release of personnel, closeout of jobsite accounts, final cost reports, and preparation of system by system basis. As start-up personnel complete a system checkout, it is formally turned over to the client. This process continues until all systems are completed.

4.4.2 Job Completion

Job closeout or completion reports are initiated by the field construction manager who, along with the manager of construction, gives initial approval. The construction manager reviews the reports and is responsible for final approval.

At the completion of the job, or portions of it, a request for acceptance of work is made in writing to the client. In accordance with contract provisions, the original copy signed by the client is kept in the project files and a copy is sent to the manager of construction at the division home office. One-year workmanship warranties usually start from this date.

At job completion, all engineering reports, drawings, radiographs, etc., are returned to division headquarters for storage. As-built drawings are delivered to the client to show any changes made during field construction or to show any specific non-designed additions.

The removal of equipment, tools, and materials is arranged well in advance of the actual release date.

4.4.3 Surplus Disposal

Surplus disposal is a major concern of field procurement. A list of surplus materials is regularly maintained throughout the construction period by a materials supervisor.

This list is submitted to the project construction manager for approval and subsequent disposal rather than allowing surplus to accumulate until construction closeout.

Under a policy of serving the client's best interest, five methods are employed:

- Client option to retain;

- Return to supplier per purchase order terms;

- Negotiated return to supplier;

- Transfer to the other jobs; and

- Public bid or sale.

4.4.4 Unfinished Business

At the completion of project, a report covering outstanding items to be resolved is submitted to the construction manager by the project superintendent, his successor, or the last man to leave the job. This report covers all unfinished business including unsatisfied clients, vendors, or contractors/subcontractors; unsettled accounts and claims; disputes over money; and any legal or contractual matters.

4.5 Contract Administration

The contract/subcontract administration is responsible for providing such services under the general guidelines of the company policies and contract conditions.

The contract administration is normally divided into site and home office contract administration and is responsible for the following:

4.5.1 Contract/Subcontract Administration

Throughout the life of a project, the subcontract administration group is responsible for providing contract/subcontract support services which include:

- Providing general and specific guidance and support to field and division management on contract/subcontract administration, interpretation, and problem solving;
- Providing jobsite training of field contract/subcontract administration personnel;
- Assisting in evaluating and selecting key personnel to staff the field contract/subcontract administration organization;
- Supporting projects by evaluating, analyzing, and negotiating claims, backcharges, etc.;
- Reviewing amendments/change orders;
- Reviewing recommendations to clients pertaining to contract/subcontract formation, bidding, and administration;

- Reviewing the performance of project contract/subcontract administration personnel through periodic onsite field reviews, analysis of reports, etc.; and

- Providing liaison and coordination with division support groups such as legal, finance and accounting, and procurement on all matters pertaining to contract/subcontract administration.

Contract/subcontract management is broken up into the following four phases:

- Preliminary;

- Formation;

- Bid and award; and

- Administration.

We shall review the first three phases briefly and concentrate on the fourth: the administration of contracts/subcontracts.

4.5.1.1 Preliminary Phase

A number of factors are considered during the preliminary phase:

- Availability of labour in the area;

- Specialized craft labour;

- Client preferences;

- Business licenses; and

- Coordination and timing of the work.

4.5.1.2 Formation Phase

The steps required during the formation of a contract are the same in all entities, only the responsibilities differ.

Procurement prepares the contract package after having received the necessary input from engineering, construction, project management, and legal and insurance personnel. The package consists of the actual agreement form and Exhibits A through E. These are shown in Figure 4-1.

The contract/subcontract agreement form names and contractor, client, work to be performed, and compensation to be paid. The exhibits are as follows:

- Exhibit A, General Terms and Conditions, describes legal rights, responsibilities, etc.;

- Exhibit B, Special Conditions, includes insurance requirements, a list of utilities, facilities, materials, and equipment to be furnished by the contractor/subcontractor, the construction schedule, and a list of progress payments;

- Exhibit C contains pricing and proposal data to be furnished by the bidder as well as the bidder's construction schedule and plans to meet it, a list of the bidder's proposed subcontract work, the construction equipment the bidder intends to utilize at the jobsite, manual/non-manual manpower and equipment schedules, and technical or special information necessary for bid evaluation;

- Exhibit D, Technical Specifications, include design criteria, material quality, and the scope of the work required; and

- Exhibit E contains a list of all applicable drawings (showing drawing number, revision number, date, and title), and the drawings themselves (drawings appear only in this portion of the package).

Figure 4.1

CONTRACT/SUBCONTRACT PACKAGE

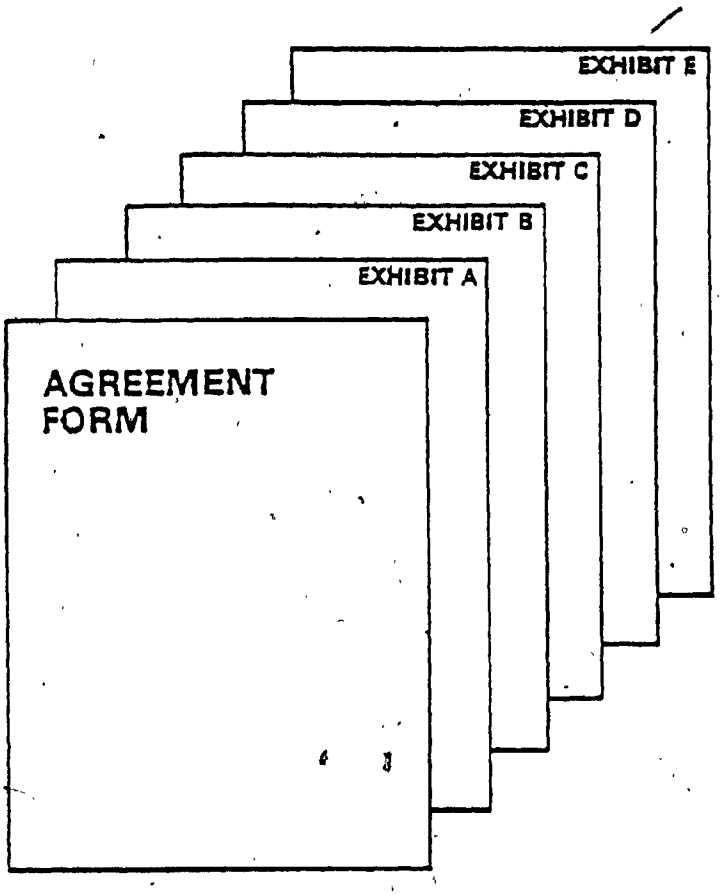


EXHIBIT A — GENERAL TERMS AND CONDITIONS

EXHIBIT B — SPECIAL CONDITIONS

EXHIBIT C — BIDDER'S PRICING AND PROPOSAL DATA, SCHEDULE, ETC.

EXHIBIT D — TECHNICAL SPECIFICATIONS

EXHIBIT E — DRAWINGS

Source: Bechtel Corporation

4.5.2 Bid and Award Phase

The completed contract document is included in the bid package, which also contains:

- Proposal Invitation Letter--the bidder is invited to bid on the work and is given instructions on how and when to submit the proposal, is given a date and contact person for a site visit, and is told where to direct questions. (Bidders are instructed to direct technical, construction, and commercial questions to procurement personnel.)

Contract/subcontract managment is broken up into the following four phases:

- Preliminary;
- Formation;
- Bid and award; and
- Administration.

We review the first three phases briefly and concentrate on the fourth: the administration of contracts/subcontracts.

4.5.2.1 Preliminary Phase

A number of factors are considered during the preliminary phase:

- Availability of labour in the area;
- Specialized craft labour;
- Client preferences;
- Business licenses;
- Coordination and timing of the work; and
- Completeness of engineering: thorough and quantitatively definite.

Instructions to Bidders--procedures for proposal submittal are defined.

General Information for the Bidders--bidders are told how to prepare their bids. Included are such items as what will be built and for whom, site location, description of site access road, climatic and seismic information, rock and soil data, etc.

Contract package (contract agreement form and Exhibits A through E).

Bidders are checked by labour relations personnel to determine their union compatibility; by construction representatives for their current work load, technical expertise, and equipment capability; and by procurement personnel for their financial strength. The client's approval is also required.

4.5.2.2 Administration Phase

Administration commences at the time a contract/subcontract has been signed by all the necessary parties and consists of ensuring that all technical, commercial, and legal provisions in a contract/subcontract are complied with by all parties. Any individual responsible for the administration of a contract/subcontract must be familiar with all of its provisions.

A homogeneous project data filing system must be available so that retrieval will be quick, accurate, and complete. Project correspondence and document distribution procedures must be provided.

When dealing with contractors/subcontractors, the following meetings are established:

- Prebid meetings and prebid site visits are necessary to introduce the bidders to the jobsite and to define the full scope of their work. Prebid site visits are conducted by the client and the construction manager's personnel. Prebid meetings are organized by the construction manager and the client and are attended by the field construction manager contracts supervisor/resident engineer, and representatives of other concerned departments;

- Preaward meetings are held with the successful bidder to ensure that the obligations of the contract/subcontract are fully understood;

- Preconstruction (kick-off) meetings are held at the jobsite with the contractor/subcontractor to review the proposed schedule and method of operation. Procedures, forms, and reports are agreed upon and drawing distribution, project rules, and work practices are established; and

- Progress review meetings are held regularly between construction manager and the contractor/subcontractor to review progress of work and current and anticipated problems; proposals, change orders, etc., are discussed. Similar meetings are held with the client to discuss the status of the project.

A formal agenda is prepared before all meetings and records of the proceedings are kept.

From an administrative point of view, the schedule is one of the most important documents in the contract/subcontract package.

The conditions listed in contracts/subcontracts usually specify the start of work date, construction duration, and completion date. Milestone dates are specified for completion of portions of the work. The flow of activities is included. Schedule provides a basis for evaluating the progress of work and a forewarning of possible delays and default situations, provides for timely delivery of construction drawings, and establishes cash flows. It is essential that the schedule is current at all times and that it reflects all changes affecting time. The contract monitoring report, a detailed schedule of quantities and manhours, is another useful document.

4.5.3 Problems

Backcharges arise when work which is the contractual responsibility of a contractor/subcontractor or vendor is performed by others. A backcharge may also result from:

- A service performed by the construction manager at the subcontractor's request which is within the subcontract scope; or
- Costs already sustained or to be sustained by construction manager as a result of actions or performance by the subcontractor which damage construction work and result in unilateral backcharges against the subcontractor's account. The subcontractor or vendor is invoiced for these backcharges. If unpaid by a set date, they can be deducted from the next progress payment.

Extra work (as opposed to changes) is considered to be substitutions, additions, or deletions of work outside the scope of the original contract/subcontract. The contractor/subcontractor is not legally obligated to perform extra work; therefore, an amendment to include such work is issued by mutual agreement.

If the contractor/subcontractor refuses to sign, he may be requested in writing by the project manager to perform the work on a cost plus basis. If time does not permit determination of the cost-time adjustment, an authorization for extra work may be issued with appropriate notations.

The contractor/subcontractor does not commence work on the changes or extra work until a notice to proceed has been issued by the contract supervisor/resident engineer. No payment is made for the work until a change order authorization has been fully executed.

The execution of change orders require division recommendation, procurement and division approval, procurement execution, and in many cases, client approval.

It is not unusual for a contractor/subcontractor's work to be interrupted. An extension may be granted for any of the following reasons:

- Unusual weather conditions (floods, landslides, etc.);

- Changes or extra work of great magnitude;

- Delay by the client or design consultant in delivering materials, equipment, drawings, or data; or

- Labor strikes in which the contractor/subcontractor is not involved.

These delays are documented in case they should lead to a claim.

If work is delayed for any reason, notification is given to the contractor/subcontractor in writing within specified time. At the end of the delay, it is determined if a cost or time adjustment should be made to the contract/subcontract. If the delay was caused by the negligence of the contractor/subcontractor, he may be requested to accelerate the work in order to minimize the impact of the delay on the project's schedule and cost. Termination of a contract/subcontract can take place due to the client or company's own convenience.

Termination cause may arise when it appears that significant problems are being encountered in prosecuting the work.

The contractor/ subcontractor is formally notified in meetings or by telephone; if the situation continues, he is officially informed of an existing basis for default which, unless rectified within a certain time limit, will lead to termination of his right-to-proceed.

In the event contractor/subcontractor does not take appropriate action during the time allowed, his right-to-proceed is terminated in accordance with the appropriate clause(s) in the contract/subcontract document.

See reference No. 11.

4.5 Final Inspection and Acceptance

The typical contract/subcontract provides that, upon written request from a contractor/ subcontractor, a joint final inspection will be made. After the responsible field engineer determines that the work has been completed and advises the contracts supervisor, project field engineer and/or resident engineer, the inspection is conducted by the contractor/subcontractor and designer or construction manager (with the client generally participating on management jobs).

Upon completion of the inspection, the contracts supervisor/resident engineer originates a contract/subcontract closeout check list.

If the work is incomplete, the field engineer prepares an itemized punch list for submittal to the contractor/subcontractor.

The field engineer inspects any necessary remedial work, and the appropriate designer's department representative makes the final inspection to verify that all corrective action has been performed.

At this time, a copy of the standard release of lien form is forwarded by field accounting to the contractor/subcontractor who executes this document and returns it to his home office or the client.

4.5.5 Contract/Subcontract Closeout

Construction contracts/subcontracts generally require construction managers to notify the client when all work is completed.

This is normally done, after it is ensured that all the items of check list have been completed and that all physical, administrative, and financial requirements of the contracts are fulfilled, upon the client's acceptance, the final holding payment is released to the contractor/ subcontractor.

4.5.6 Final Payment and Release of Lien

The contract supervisor/resident engineer initiates the contract/subcontract closeout check list, reaches agreement with the contractor/ subcontractor on the amount of the final invoice, and solicits the notarized release of lien and certification of completion from the contractor/ subcontractor.

When the checklist is completely signed off by each department (acknowledging compliance of the contractor/subcontractor with all the items listed) and the final invoice and signed release of lien are received from the contractor/ subcontractor, the contract supervisor/resident engineer approves final payment.

The contractor/subcontractor is notified in writing of final acceptance.

4.6 Quality Assurance

The quality assurance program, usually instituted by the construction management firm, under the policies of its company, outlines the importance of monitoring the quality at site and consists of instructions, drawings, controlling the work in accordance with the company policies and acceptable construction standards.

This systematically provides for varifying and documenting that work performed meets established standards.

The field construction management is normally responsible for defining the quality assurance program requirements, implementing it and evaluating its effectiveness by means of audits, surveillance, and monitoring. Some times site visits by the client's representative or design consultant's representative makes sure that the work carried out ensures the established quality and standards.

The essential elements of a quality assurance program are:

- Plans and procedures;
- Indoctrination and training, if necessary;
- Management involvement;
- Independent review, inspection, and test;

- Corrective action; and

- Records.

Everyone performing or responsible for the perforance of an activity affecting quality is in theory responsible for quality assurance. However, the quality assurance program ensures:

- That a formal quality assurance program is established and effectively implemented; and

- Quality verification and documentation.

The quality assurance functions, which may be part of a functional group or department, are organizationally independent of the work. They may include:

- Quality engineering--a part of the Engineering Department which is responsible for monitoring the design control system;

- Construction quality control--a part of the Construction Department which is responsible for quality verification and documentation and quality surveillance of subcontractor work at the construction site.

- Procurement supplier quality--a part of the Procurement Department which is responsible for monitoring, surveillance of subcontractor work at the construction site; and

- The Quality Assurance Department--a management function which is responsible for defining the quality assurance program policy, verifying its implementation and evaluating its effectiveness through monitoring, surveillance, and audit.

4.6.1 Field Activities

Quality assurance engineers located at the jobsite assist the project quality assurance engineer, who is a member of the project engineering team.

An audit and surveillance system is set up to monitor project quality activities, to determine compliance with program requirements, and to ensure that the project establishes and maintains an effective system of control, storage, and retrieval of quality assurance documentation.

Spot checks are made of first-level inspection during receipt, installation, and final inspection of critical items defined by the quality surveillance.

Handling and storage control is reviewed and periodic checks are made of storage facilities.

Selective reviews are made of receiving, installation, and final inspection reports after they have been reviewed by the project field engineer or the quality control engineer to ensure that the inspection process conformed to procedures in the field inspection manual, specifications, and other sources.

Spot checks are made of quality assurance and quality control records and documents.

4.6.2 Quality Verification

Quality verification is the process of verifying that materials, equipment, components, and all other items important to quality satisfy design specifications. It may be accomplished by monitoring, surveillance, or inspection, and includes providing documentation (quality verification documents) attesting to conformance with specifications.

Although verification is the responsibility of the organization performing the work, it is accomplished by individuals other than those responsible for doing the work.

4.6.3 Audits, Monitoring, and Surveillance

Audits, monitoring, and surveillance generally describe the regular activities of quality assurance engineers who verify the implementation of the quality assurance program and evaluate its effectiveness.

Audits are planned and scheduled according to a master audit plan. Internal audits are conducted at two levels: project audits and quality assurance management audits. External audits are conducted of suppliers and contractors.

Monitoring and surveillance ganerally describe routine activities such as reviewing procedures, documents, records, etc., and observing activities.

4.6.4 Field Construction Engineering

Field construction engineering is responsible for the quality control of the material. This includes knowing what has been installed and how much remains to be used. Quantity control includes making take-offs, prepareing purchase requisitions, maintaining records of work done, forecasting the remaining work, and monitoring actual progress so it can be compared to a predetermined schedule.

4.6.5 Quantity Take-Off and Material Control

The project field engineer is responsible for the following take-offs performed by field engineers under his supervision.

- Quantities of work to assist in scheduling;
- Quantities of construction materials for purchasing;
- Quantities of work for monitoring progress;
- Quantities for payment to suppliers; and
- Quantities for As-Built records.

The civil ledgers contain quantities of concrete, precast concrete panels, reinforced steel, forms, structural steel, etc. The piping ledgers contain quantities of large and small pipe, hangers and supports, and valves. The electrical ledger contains quantities of terminations, wire and cable, cable trays, and conduit.

Bulk quantity data become more definitive as design engineering progresses. In the early phases of the project, design allowances based on similar projects are used for quantity projection; later, estimates based on take-offs from area drawings replace the allowances.

When construction drawings, pipe isometrics, etc., become available, detailed take-offs replace the estimated quantities. Finally, the actual installed quantities as reported by the field are used. Deviations from budgeted quantities are trended as part of the design cost trending program.

A quantity control program is initiated upon completion of the first or second preliminary estimate and lasts until engineering is essentially completed. The engineering design is monitored to develop and maintain bulk quantity ledgers for civil, piping, and electrical items. Items are identified to the degree necessary for project control. Bulk quantities are identified by facility area, engineering system number, subcontract package number, etc.

A quantity tracking system is maintained to control the delivery and installation of all the equipment. Field procedures are developed for setting all equipment, and survey controls and documentation are maintained for its installation.

CHAPTER 5

5.0 DOMESTIC VERSUS INTERNATONAL PROJECTS

5.1 Introduction

It is observable that some project managers are more successful on international projects than others and in the followig chapter, we will discuss a few items which are important for a project manager to know in order for him to conclude the project successfully.

The limited information regarding the geography of the site; the people; its culture; and essential facilities such as transportation, communication, availability of skilled workers, etc., demand a project management team to adopt a new approach in the development of the fundamental elements of a project, which include procurement, planning and scheduling, and manpower staffing.

Perhaps the most significant factor on overseas projects is that the project manager has to make decisions in relative isolation from the feedback he gets from his headquarters and colleagues. It is easier to lose perspective to all, a project, or the people working on it to get side tracked on tangential issues.

The major overseas industrial projects, specially those built in the developing countries, involve the financing from various international banks, governments, and sometimes international bodies such at the United Nations or World Bank. The scope of work for the project manager thus increases because of his responsibility to coordinate and communicate with the financial agencies involved, under the terms and conditions of the contract.

The handling of the problems associated with the construction facilities, camp facilities, staffing, and local laws and regulations can also be a unique experience for a foreign project manager. Some of these things have been discussed here, however, the unique characteristics of a given project in a given country can only be resolved accordingly. Therefore, in this chapter, the problems of general nature have been discussed, which have been usually dealt with by the EPC firms in various developing countries.

International projects are different than domestic projects in the planning, scheduling, procurement of the equipment and material, and staffing of the projects.

5.2 Pre-Planning

The usual amount of effort required to plan and organize the work actually starts in the early stages of the project.

It is often necessary to build docks and establish support facilities to accommodate construction material and field staff prior to construction.

The successful construction planning requires close coordination and cooperation of construction, engineering, procurement, finance and accounting, cost, planning and scheduling, and project management personnel. The individuals most involved are site manager, project manager, procurement manager, planning and scheduling manager, and cost engineer. Their input starts even before detailed engineering starts.

Key members of the construction staff participate in the pre-planning of activities in the business stage. The pre-planning stage activities involve visits to the site. the objectives of such visits are to explore the availability of roads, manpower, docks, and utilities. It may also involve the design and procurement of temporary support facilities, housing, roads, docks, water and sewage systems, fabrication and maintenance shops, warehouse and field offices, etc.

The overseas project is complex in paper work. The purchase of major equipment has to be done from the country of finance or loans or in some cases from several countries.

This requires approval of the authorities providing the finance, shipment from various ports, clearance at various docks, and inspection o the authorities involved. this makes every item to a long lead item, especially in a remote location.

Surplus is purchased to cover pilferage and damage. Small tools, especially, have a high mortality rate on foreign projects.. Theft is commonplace and can only partially be controlled through gate checks. Local employees often do not know how to use the equipment and tools, therefore, a great number are damaged. Correct equipment handling is taught and changeable parts must be ordered because spare parts dealers do not exist on remote projects.

When ordering equipment, the emphasis is on automation becuase it is easier to train an operator to use automated equipment. When purchasing tools, heavy duty models with sealed bearings are preferred. Maintenance is an important factor on foreign jobs.

5.3 Logistics

Few things are as important to an overseas job as supplying material to the jobsite; tools, food fuel, consumables, equipment, drawings, licenses, and custom clearance require a great deal of attention by engineering and construction groups.

Items which could be obtained here in two weeks may require up to three months to get there due to transportation and custom clearance. Some items can be expedited on an emergency basis, but large projects cannot be run on emergency supplies. Therefore, logistics planning is extremely important and people must be selected for this work who are experienced in this field and can cope with the foreign environment.

The success of a good logistics plan depends on the ability of personnel in the field organization to identify needs on a timely basis. They must have an efficient system for receiving, handling, transporting, and warehousing materials and camp supplies. A substantial part of the logistics function is related to procurment but, on a large project, dealings with airlines, banks, and retail businesses also play an important role.

Construction equipment on a foreign job is often client-owned simply because the cost of freight and handling, as well as transit time, make it uneconomical to rent or lease. In most cases, the client will need some of the equipment after constuction is completed. Proposals usually include the construction manager's basic plan for supplying, operating, and maintaining construction equipment as well as disposing it off after job completion.

The availability of equipment in the country and through contractors is incuded in the plan.

Temporary facilities generally represent a large portion of the cost of an overseas project with a large work force. They must be described in detail to the client, in order to avoid future problems in justifying the costs. The client must also be informed of the necessity of the temporary emergency medical facilities especially in the remote locations.

5.4 Procurement

Worldwide procurement for domestic and international projects demands an in-depth organization and the implementation of well-planned procedures. International projects are always complex and costly and, because procurement is an integral part of such projects, each of its functions is essential for successful completion.

International procurement is influenced by various factors that are different than in North America:

- Language barriers;
- Currency for payment (as currency fluctuates, the risk of loss increases);

- Import restrictions and duties (the Arab boycott, for example, for negative lists which identify items that cannot be imported, usually because they are available locally and the country wants to encourage local industry). High duties or penalties result from importing items on the negative list. Some developing countries have other complex export restrictions. For instance, Algeria require a detailed list provided in advance of all items to be imported for a project during the year. Items not shown on the list are delayed or cannot be imported at all;

- Special taxes or tax credits--special taxes are enacted to encourage local commerce and discourage imports. On the other hand, tax credits are available if they might encourage business in a developing country (for instance, Brazil waives state and federal taxes on capital equipment when it is to be used to produce a product for export);

- Codes and Standards--an evaluation of the standards in the host country promotes an understanding of the local supply industry and results in improved procurement efforts;

- Market and supply services;

- Business conditions and customs;

- Laws;

- Code and ethics;

- Export shipping requirements; and

- Special financing requirements--financing may stem from client equity funds, an agency of the U.S. or Canadian governments, a foreign government, or a combination of all three and each has a different rules regarding procurement.

The proper stipulation of shipping terms in the purchase order/contract is especially important on overseas shipments because of the complexities of claims and insurance.

On overseas projects, expediting involvement continues after an order has been shipped from the supplier's plant. Expediting and traffic are closely coordinated to ensure that materials meet dockside or airport delivery requirements in order to be exported on schedule.

Field procurement operations on international projects can be very complicated because of customs and import requirements. A specialized knowledge of import licenses and customs clearances and declarations is required to accurately position the incoming goods.

Because foreign projects require local procurement as much as possible, procurement practices must be adapted to fit the capability of local industries.

5.5 Camp Facilities

A well designed and well organized camp that provides good food, good housing, and adequate different kind of recreational facilities is essential for the success of a project. Camp conditions affect a person's ability to perform the job. If personnel is unhappy about the living quarters, food, medical services, or recreational facilities, he will not be happy at his job. The results are lower productivity and absenteeism which affect the schedule and quality of the completed project.

Maintaining high standards in a camp always presents a challenge. With the standard of living around the world steadily increasing, there is an ever-growing demand for good medical, educational, and recreational facilities in addition to good food and adequate housing.

On a large international project, a camp represents an important portion of the project cost; therefore, a great deal of planning and follow-through is required. Early consideration is given to:

- Population--camp manpower schedules showing work force requirements through the life of the project; and

- Facilities--temporary and/or permanent buildings versus trailers and/or tents to be used for housing, kitchens, mess halls, commissary, schools, and medical and recreational facilities.

Quality of facilities and services cannot be underrated, especially in housing, catering operators, water, heat, air conditioning and sewage systems, and recreational programs.

Living quarters in the camp should be designed to be similar to those available to the employees in their home country. For example, the air conditioning is necessary for the expatriate in the tropical climate wherever it is not provided for the local people. Water has to be specially treated to free if from contamination and make it safe to drink. On all jobs, the water supply, sewage treatment, good sanitation, and general environmental standards are monitored and controlled by qualified personnel.

Schools and a hospital for expatriates are provided and are usually staffed with highly qualified personnel. The size and extent of the medical facility depends on the remoteness of project.

Also, an effort is provided for religious services to all denominations, especially on large jobs.

5.6 Compounds

On some foreign projects, it is appropriate to locate housing facilities on compounds protected by special security measures, i.e., a fence or wall and gatekeepers. Employees using these facilities are well protected and made to feel as comfortable and secure as they would be in the U.S. or Canada.

5.7 Manpower Staffing and Training

5.7.1 General

The single most important item on a project is the people. Both manual and non-manual employees should be recruited, transported to the jobsite, housed, trained, and assigned the work for which they are qualified. This applies not only to experienced managers and supervisors but to the local and international staff as well. The availability, cost, skills, and quality of national nad international labour and the plan for recruiting, training, and utilizing this labor are of prime concern to everyone on an international project (See Figure 5.1).

FIGURE 5 -1
MAJOR CONSIDERATIONS

PREPLANNING AND ORGANIZATION OF:

THE WORK FORCE

LOGISTICS

PROCUREMENT EFFORT

5.7.2 Manpower Staffing

Local recruiting plays a major role on the overseas projects. U.S. or Canadian expatriots are generally limited to the management and supervisory levels. Because of growing nationalism and competition in other countries, Foreign expatriots can be justified only on the basis of special capabilities and expertise not available in the host countries.

Uniform and complete employment conditions have to be developed for each project. These are usually influenced by the project's cost and particularly the best use of each of labor source, a decision should be made on the labor mix for basic construction organization, climate, working conditions, local labor laws, availability of housing and transportation, and client requirements. An assessment of labor unions should also be made. In some countries they do not exist, in others, although existent, they are political rather than labor oriented.

Scheduling and planning, when local nationals are employed must take into consideration local regulations and practices such as breaks, religious practices, caste restrictions, etc.

On international projects, it is normal to have longer working hours than on domestic jobs. There are several reasons for this:

- Reduction of peak manpower requirements to minimize the cost of construction;
- Better utilization of construction equipment;
- Minimization of the cost of mobilizing and demobilizing of imported labor; and
- Keeping personnel busy, especially in remote locations.

The organization chart on a foreign job also differs from that of a domestic job. Additional positions include camp people, transport people for barges, customs and logistics people, non-manual people, spare parts warehousement, and training specialists.

U.S. or Canadian companies have to attract good people on the overseas jobs, especially in remote locations, by providing incentives such as:

- Rest and recreation (R & R)--taking into consideration the unusual living and working conditions of the particular site, the length, frequency, allowance, and designated R & R locations are determined and included in the employment conditions for individuals and families on international assignements;

- Annual home leave--for the employee and dependents after 12 months of assignment;

- Educational allowances--if an adequate school (this usually applies to grades 10 and up) is not available at the site, an "away-from-post" allowance is provided for educating dependent children; suitable arrangements are made for students to attend schools in Europe, England, or the U.S.;

- International compensation plan--the plan compensates for the harsh conditions in some areas, provides additional take-home pay to offset excess costs often found in a foreign country, and responds to changes in economic factors such as currency fluctuations. the base salary serves as a foundation for the international compensation plan;

- Foreign service premium--a percentage of the base salary up to a maximum of 25%; the actual percentage depends on the relationship between U.S. and foreign income taxes and may differ from location to location. The foreign service premium is a partial payment of the basic incentive, paid monthly, and may be supplemented by an incentive maintenance payment;

- Hardship allowances--or recognize and compensate for unusual physical hardship, extraordinarily difficult living conditions, isolation, and other unattractive aspects associated with a specific location, hardship allowances are paid; they vary from 0% to 25% of the U.S. base salary depending on locations;

- Completion incentive--a percentage of the U.S. base salary which is intended to encourage continuity of work under hardship conditions; it is usually paid at the end of the assignment but may be paid annually;

- Special area allowance--a percentage of the base salary intended for use only in certain situations where additional incentive is needed to attract and retain competent staff; and

- Cost differential allowance--intended to compensate for the difference in the cost of goods, services, and housing at locations where the cost of similar items exceeds the U.S. costs.

With the first time expatriate, morale is inclined to fluctuate widely, depending on conditions, efforts must be made to improve it. Typically the newcomer to a foreign country is somewhat scared on arrival, then excited as new prospects and challenges appear.

Depression sets in as he or she realizes the full extent of the problems to be surmounted: living conditions, language, and office relationships. About six months after arrival, he or she usually hits bottom. With a little counselling and encouragement at that point, the employee can be expected to climb back and slowly become a veteran. Those judged unlikely to make it should be counselled to return.

5.7.3 Training

Obtaining the qualified local personnel is difficult in some countries, and to bring the expatriate is sometimes expensive, also due to the growing nationalism, it is desirable to look into hiring the local people and provide them proper training. Some companies have aquired necessary experience and capabilities of training large number of people in locations related to most facets of project work. In the early 1950's skill training was limited to specific activities such as pipe welding and installation of cable trays with some of the more talented workers receiving additional training necessry for them to become instructors and supervisors of small groups.

5.8 Legal, Tax, and Insurance

5.8.1 Legal

All operations in Canada and the U.S. are conducted under a system of federal, provincial, and local laws with which most of us are familiar. Many risks are covered by insurance. Personnel operating businesses are acquainted with the tax system.

Information pertaining to licensing obligations is known or available. Overseas, however, these activities vary from country to country and from culture to culture.

In countries where the law is based on Anglo-Saxon practices (equity) legal rights and rules are essentially the same as in the U.S. or Canada. Europe (France in particular) and South America follow the Napoleonic Code modified by local structure. Basically, the difference between the two forms of law is that under the Napoleonic law a man is guilty until proven innocent whereas in the U.S. a man is innocent until proven guilty.

The Islamic Code (in countries like Saudi Arabia) follows the Koran quite closely. In Islamic countries which were under British influence (such as Egypt), combinations of the English Common Law and the Islamic Code are used whereas in Islamic countries like Syria and Lebanon which were French mandates, the Napoleonic Code is combined with the Islamic Code.

In other parts of the world, mostly in Eastern Asia, the legal system may be based on the teachings of Buddha, Confucius, or other local prophets.

When working in a foreign country, one must consider the law and legal philosophies of the country in which the work is being performed. For instance, the foreign competitors operating in their home countries are generally free to negotiate the commercial terms of their contracts without serious interference from their governments. Canadian or U.S. companies, however, may be required by application of U.S. or Canadian law to operate differently.

As an example, a U.S. entity cannot agree to provide technical data (drawings, specifications, even ideas) which originated in the U.S. without first obtaining certain assurances from the foreign client which will comply with the applicable U.S. requirements.

A U.S. entity cannot agree to provide financing without first considering the U.S. Foreign Direct Investment Controls.

5.8.2 Taxes

Taxes are given serious consideration in any international contract negotiations.

People in other countries have different views about taxes than we do here. Here, an important part of the government's revenue is derived from income taxes established by law. In some European countries, such as Italy, the tax collector's judgement of one's income determines one's taxes. In most of Europe, a tax is established on every transaction; these taxes on commercial turnover constitute a major source of revenue.

Developing countries, in order to protect local emerging industry, encourage (or, in many cases, require) local participation in large national interest projects, establish restrictive foreign exchange control policies that inhibit foreigners from doing business there. Sometimes, the tax system for foreigners is so stringent that the net profit after tax is reduced to such a low level that it is ofen uneconomical to do business.

Foreign employees and the company organization must comply with all applicable local tax laws when working overseas.

5.8.3 Insurance

The insurance program is an important part of an overseas project. Most overseas clients are not as insurance concious as we in North America are. As a result, local contractors or engineers usually do not encounter much difficulty from their clients. This attitude, however, does not apply to the foreign contractors.

In some countries, like Algeria, it is illegal to obtain insurance from a carrier who is not authorized as an insurer in that country.

On overseas projects, a foreign company usually takes the following steps:

- Company works with brokers who collaborate to the extent necessary with local insurance companies;

- The insurance factor is considered even before entering into a contract so that most of the risk can be eliminated by the contract terms; and

- Close cooperation between legal, insurance, and division control groups is very important.

The insurance issues on international work are so varied and complex that some companies rely on their local legal counsels and insurance representatives to discover any rules, customs, and laws that may be unusual and to develop preferred contract and insurance program arrangements with foreign brokers and insurers.

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