A STUDY OF CAPITAL COST ESTIMATION FOR HEAVY INDUSTRIAL PLANTS

by

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ABSTRACT

The objective of this technical paper is to report capital cost estimating approaches used by a major project management company to prepare capital cost estimate for the construction of heavy industrial plants. In the first chapter, a description of factored capital cost estimating approach is given. In chapter two, the role of capital cost estimating in the management of construction projects is examined and the classification of different types of cost estimates according to the level of estimate required are described. In chapter three, capital cost estimating approaches, applied to heavy industrial plants are presented. Contingency and Escalation – two of the most important factors in estimation at this early stage of project development – is discussed in chapter four. Chapter five and six contain general discussions of risk analysis and project financing which play important roles in engineering economic decisions in today's competitive

market for heavy industrial construction. In the last chapter conclusions and recommendations are made concerning the strong and weak points of this estimating technique and suggestions for possible improvement of the approach described herein.

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Chapter 1

INTERNATIONAL CAPITAL COST ESTIMATE FOR HEAVY INDUSTRIAL PLANTS

1. INTRODUCTION

Present-day construction projects, particularly those in the international scene, represent a very real challenge in the formulation and control of capital cost. Accurate estimating of initial heavy industrial plant cost is becoming more difficult every day due to changes in construction size and complexity, remoteness of construction site, escalation costs as well as environmental aspects. Changing engineering concepts which might range from a few words and sketches to a highly-developed design package are becoming more complicated. International Capital Cost Estimate must cover careful studies of the local market and the many components of the construction estimate such as equipment and material, labor, indirect costs, contracting, shipping, taxes and duties, currency fluctuations, escalation, schedules, finance and profit. Good capital cost estimating results in favorable management decisions for feasibility study or overall capital planning and budgeting of an international construction project.

This paper will examine the factored-estimating approach used in the preparation of a proposal-type (Design-Construct) estimate for capital cost of heavy industrial projects in the international scene. The approach, applied to Mineral Processing, Petro-Chemical, Pulp and Paper and Nuclear Thermal Power Plants will not produce a good estimate without the personal feeling and judgment element needed for this type of estimate. Contingency and Escalation — two of the most important factors of the estimate at this very early stage of project development — will be discussed. A general discussion of Risk Analysis and Project Financing will be included since they play important roles in engineering economic decisions for today's competitive market in heavy industrial construction.

Chapter 2

CAPITAL COST ESTIMATING IN PROJECT MANAGEMENT

The objectives of this chapter are:

(i) to classify different types of estimates based upon the degree of accuracy and the purpose of the estimate

(ii) to examine the importance of capital cost estimating in construction project management

(iii) to define the role of the estimating function in a project team.

Capital cost estimating is one of the most important Project Management tools used in planning and achieving the optimum balance between Quality, Cost and Time — the three interrelated parameters in every construction project — each of which influences and is influenced by the other two. Fig. 1 illustrates the basic objective of Project Management.

Efficient capital cost estimating must help project management to optimize the relationship between these three parameters so that the accomplishment of the project is attained at the lowest practical cost and in the shortest practical time with acceptable quality.

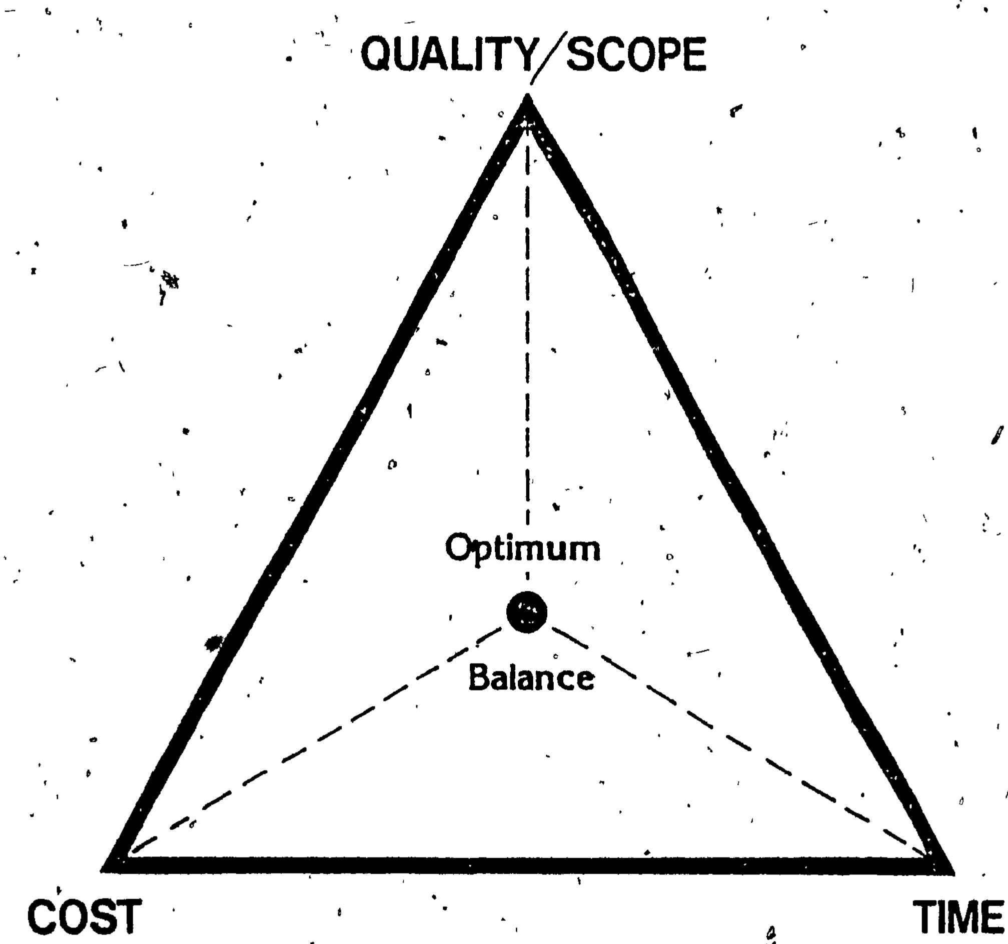


Fig. 1 Basic Objective of Project Management [17]

The role of capital cost estimating in Project Management is a continuous process of cost analysis and evaluation from feasibility, proposal, through the design, procurement, construction and commissioning stages, to completion of the project.

Fig. 2 gives an overall view of estimating functions in the management hierarchy of an Engineering-Procurement-Construction-Commissioning Project.

Thus, project organization is based on the principle of a task force under the leadership of a project manager who is ultimately responsible for scope, quality, cost, time and resources on his assigned project. The project manager coordinates the efforts of the engineering, procurement, construction and commissioning managers using the tools of planning and control provided to him by a project estimator, a project planner and a project cost controller assigned to his project. The project team is supported, if necessary, by senior members at the divisional level and functional levels at the corporate level of the company. Fig. 3 illustrates the overall interaction of a Project Task Force in an Engineering-Procurement-Construction Project — a project in which commissioning work is not under the scope of work of the engineering firm.

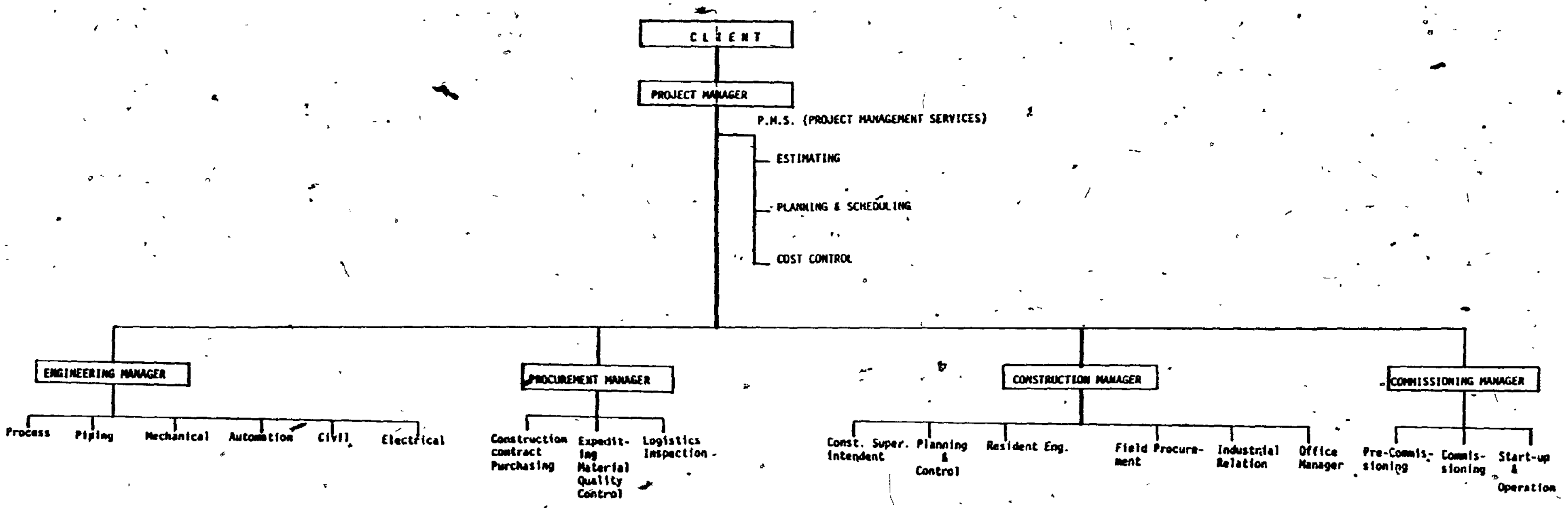


Fig. 2 Project Management Organization Chart

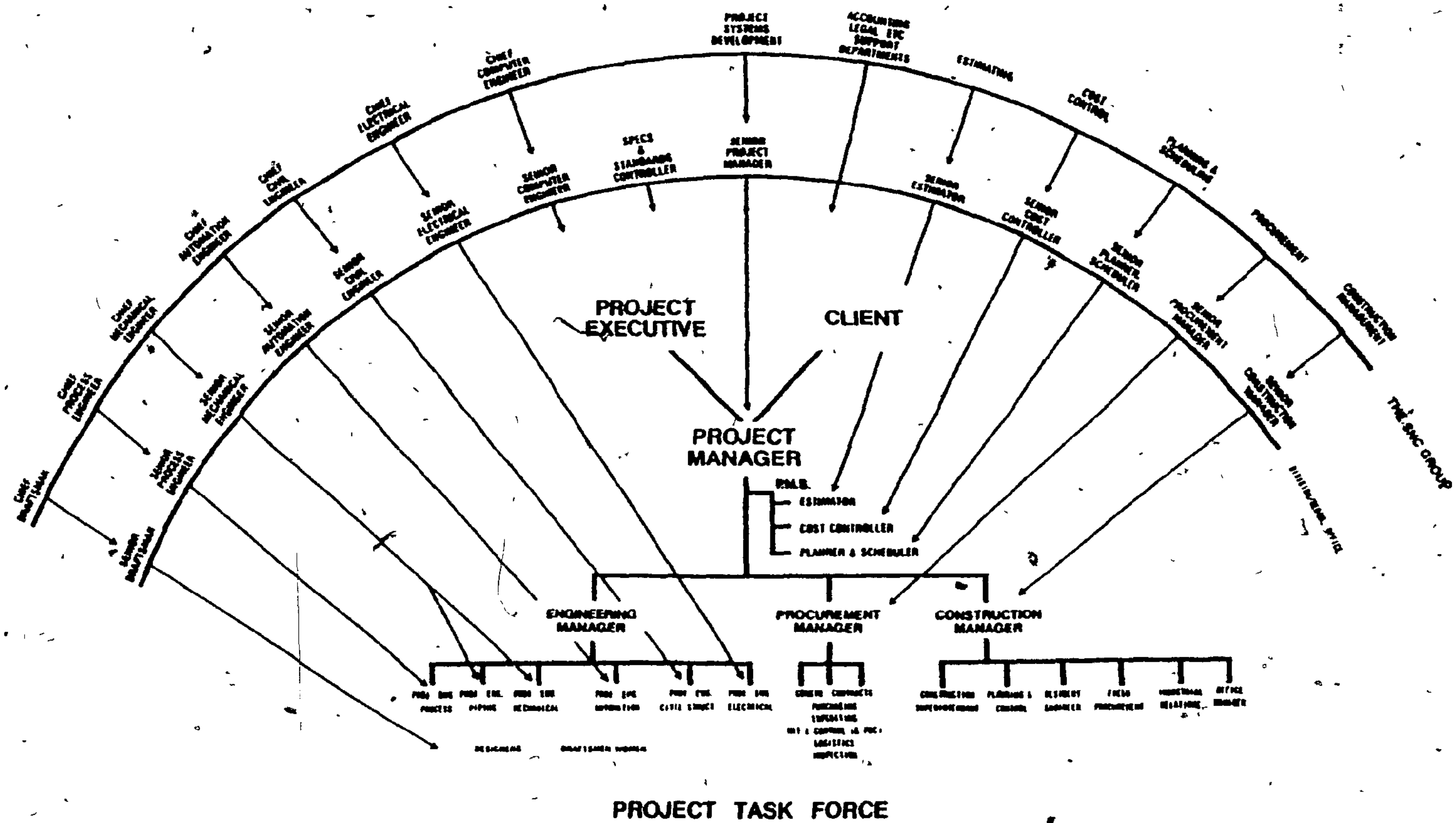


Fig. 3 Project Task Force in an Engineering-Procurement-Construction Project [17]

2.1 TYPES OF ESTIMATES

The classification of estimates by "types" is based upon the degree of accuracy and the purpose of the estimate, which are in turn directly related to the amount and detail of the information available and the procedure followed in preparing the estimate. Various types of estimates are described as follows:

2.1.1 ORDER OF MAGNITUDE ESTIMATE

During the initial consideration of a new project, an order of magnitude estimate is usually developed in order to enable the owner to decide whether the study of the project should be continued or not. If the decision is to continue, a feasibility study will be done. An order of magnitude estimate is prepared by factoring techniques, with minimal input information. This technique consists of multiplying the calculated costs by factors, established from historical data for similar projects in the past. Its purpose is to provide a quick and informal figure to roughly assess the cost of a project or part of a project. Accuracy range is no better than plus or minus 20% The estimate accuracy is the relationship of the estimate cost to the actual cost for the same facility described at the time of the estimate and hence is all inconclusive.

2.1.2 PRELIMINARY ESTIMATE

The preliminary estimate is a more refined factored estimate. It is normally prepared as part of a feasibility study after preliminary flowsheets, preliminary sketches and preliminary equipment lists have been prepared. In preparing a preliminary estimate, it is normal to obtain approximate prices from suppliers for major items of equipment and to estimate (or "guesstimate") minor equipment by experience on past projects. Other costs are estimated by factoring. Accuracy range should be within plus or minus 15% to 20%. This type of estimate is intended to provide a preliminary budget for a project and is adequate to enable the owner to decide whether he should proceed to the next stage in the development of the project ... i.e., the preliminary engineering.

2.1.3 DEFINITIVE ESTIMATE

Its purpose is to define the scope and the cost of a proposed project with sufficient accuracy to provide a sound basis for deciding whether to proceed with the detailed design and eventually with the construction of the project. If the project does get approval to go ahead, the definitive estimate becomes the guide for the development of the design and the yardstick for evaluating and controlling costs. It is prepared when preliminary engineering is substantially completed (equivalent to about 20% of final design), using a combination of quantity take-offs, conceptual quantity evaluation and factorization. Accuracy range within plus or minus 10%.

Minimum information required for preparation of a definitive estimate are as follows:

- Flow sheets
- Equipment lists, motor lists, instrument lists
- Fairly completed equipment layouts
- General arrangement of piping layout
- Electrical single-line diagram
- Fairly completed site layout with ground elevations
- Soil tests and determination of types of foundations, sketches of major foundations
- Structural sketches including cross sections of buildings
- Type and extent of finished areas in buildings
- General indication of utility and other services required

Design-and-Build Estimate

A design-and-build estimate is in reality a special type of definitive estimate. Its special character is that it is the basis for a construction contract carrying a "firm price" or a "guaranteed maximum price" and this involves a substantial commitment by the engineering firm bidding for the job. The capital cost estimate discussed in this paper falls into the category of design-and-build estimate.

The information available for the preparation of a design-and-build estimate is frequently less complete than that required for the definitive estimate because the estimate is prepared at an earlier stage than the definitive estimate. In fact, only after the engineering firm is selected to build the plant based on the design-and-build estimate can the preparation of the definitive estimate begin. Therefore, it is necessary to analyse the information thoroughly and to use great caution in evaluation of the contingency allowance.

Furthermore, a design-and-build estimate must include an allowance to cover the risk factor which is inherent in all construction contracts. This risk factor allowance which is quite distinct from, and in addition to, the contingency allowance, will depend upon a number of factors such as: the possible effect of unusually bad weather during critical parts of the construction program, possible delays due to labor disputes or due to difficulty in recruiting skilled labor or to non-delivery of important items of equipment, inefficiency and additional cost due to the necessity of crowding certain portions of the work into a schedule which may be actually too tight, and other hazards associated with the performance of the construction work. The risk factor must be taken into consideration carefully because this is a special type of estimate where a high commitment from the engineering firm is involved ... i.e., to offer to the client a firm-price contract.

In a design-and-build estimate, the scope of work and the standard of quality of the project will usually be defined partly by preliminary or rudimentary drawings or sketches and partly by a statement of performance requirements incorporated in an outline specification.

Because of the financial commitment involved, it is extremely important that these documents be carefully checked against the estimate, not only by the estimator but also by the design engineer, to ensure that they are completely compatible and sufficiently specific. Later, when the working drawings are being prepared, it will be the duty of the design engineer to follow them closely to ensure that the design does not go beyond the specified requirements and that the most economical means are adopted to meet these requirements.

The design-and-build estimate is to be used as a basis for a proposal (hence, proposal-type estimate as sometimes referred to in this report) which involves a financial commitment by the engineering firm in the form of a "firm-price" or "guaranteed maximum cost" proposal. In this case, the estimate should be reviewed by a committee consisting of the top-management officers, the project manager and the project estimator. The purpose of this review is not to relieve the project estimator of his proper responsibility but rather to enable the individuals who will be responsible for setting the price to acquire an appreciation for the risk factor involved in the financial commitment of the company. This kind of review is not necessary for other kinds of estimates. Site visit by the project estimator in the case of design-and-build estimate is a must.

Accuracy range of design-and-build estimate should be from 10% to 15%. the degree of accuracy is based on "in-house" information of the estimating department at Montreal-based S.N.C. Group.

Target Cost Estimate

The target cost estimate is the end result of a Definitive Estimate as approved by the client. It represents the capital investment target within which design, procurement and construction must be carried out to achieve the optimum balance of quality, cost and time in completing the scope of work established in the definitive estimate.

Control Estimate

This is a cost estimate of a part of a project prepared at appropriate intervals, or for the entire design as detailed design progresses to assist designers to control the design so as to keep it compatible with the scope and cost established in the target. This estimate is based on the design drawings. Discrepancies between the definitive estimate and the control estimate may initiate revision of the design.
The control estimate is also for use in making monthly cost reports.
The purposes of the control estimate are:

i) to develop designed quantities and to compare them with original quantities established conceptually or on allowance basis during the definitive estimate

ii) to estimate the portions of the project and compare the cost with the equivalent cost of that portion carried in the definitive estimate

iii) to provide the construction site with a list of the latest quantities of the portion of the project where design is substantially completed

iv) to provide the cost control department with the "Estimate-complete" – an estimate of additional expenditures to a committed amount necessary to complete a work item – for cost reporting purposes

v) to provide the Project Manager with a tool to assess deviations and take measures to correct or minimize these deviations

Thus, the definitive estimate defines the scope of the project as it was conceived at the time the decision was taken to proceed with it, and the anticipated cost based upon this scope. The control estimate, on the other hand, indicates the anticipated cost of carrying out the project as actually designed and taking into account the conditions (including labor rates and availability, transportation problems, foundation problems, etc.) pertaining to a particular site at a particular time. The definitive estimate always includes some factoring whereas the control estimate is prepared from a fully detailed quantity take-off and is in "cost-unit oriented" format.

Control estimates are prepared when detailed design has progressed to about 50% to 75% of a specific cost package.

Tender Check Estimate

A tender check estimate is a detailed cost estimate prepared for each "contract package" to ensure that the design was, in fact, compatible with the equivalent amount of cost carried in the target for the scope of the package in question. It is a detailed estimate based on complete drawings and specifications of a project or part of a project (package). It is intended to be used as a tool:

i) to verify before tender calls if the design of the project or package has conformed to the equivalent scope and target cost established in the definitive estimate

ii) to evaluate a contractor's bid and make recommendations

iii) to make decisions on award of contract

Tender check estimates are made when detailed design has progressed to about 90% to 95% of the contract package. Types of Capital Cost Estimates are indicated in Fig. 4.

Different phases of a properly-managed project are concept, feasibility study, pre-planning, planning, engineer/procure/construct (EPC) and commissioning. Pre-planning is an organized approach to the development of a plan for the project. The following figure indicates the degree of estimating involvement during these phases of the project. Fig. 5 illustrates different phases of a project and the estimating input through these phases.

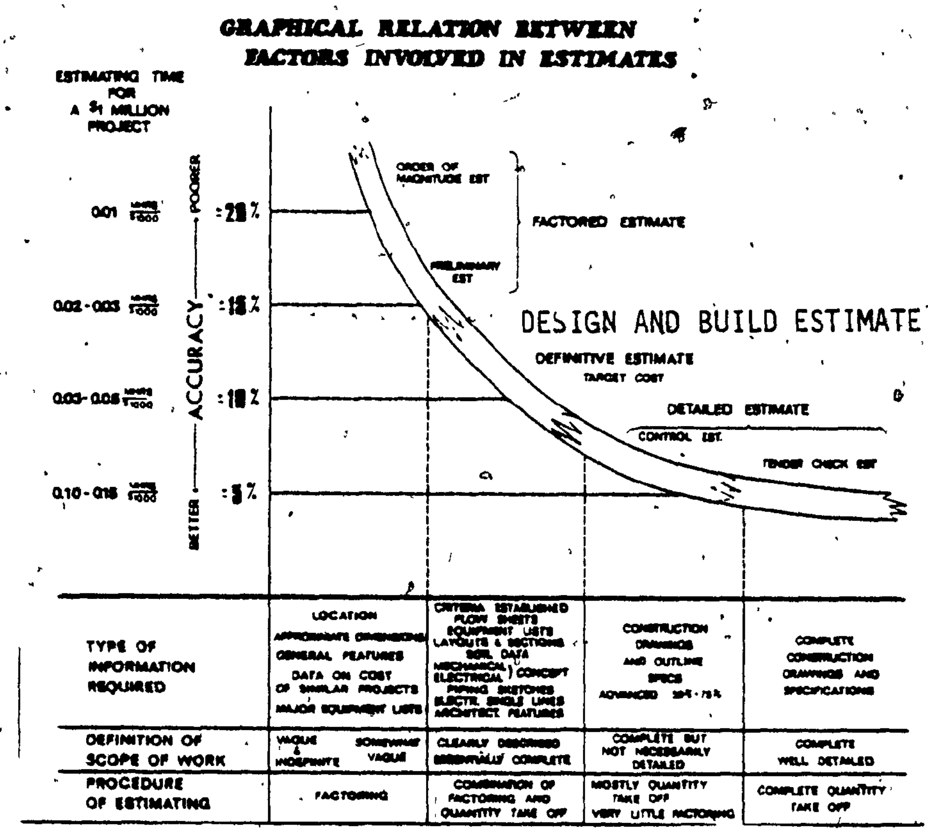
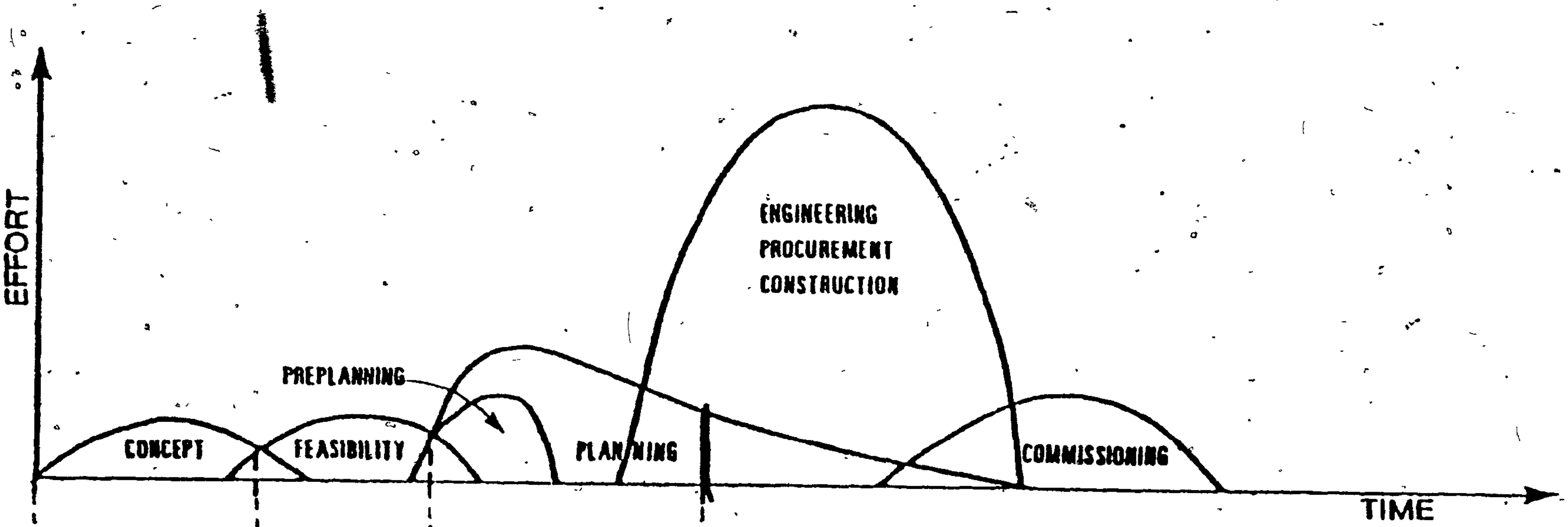


Fig. 4 Graphical Relation Between Factors Involved in Capital Cost Estimates [17]



- Order of magnitude estimate	- Preliminary estimate - Value Engineering - Local Survey	- Pre-planning - Coding - Bid Package - Definitive Estimate (target) - Value Engineering - Change Control	- Value Engineering - Control Estimate - Tender Check Estimate - Project Historical Data - Forecast-to-complete estimate - Productivity, escalation, market trend - claim and change order estimate

Fig. 5 Project Phases estimating Involvement

(For detailed interaction of different disciplines with project phases, see Appendix A).

2.2 THE IMPORTANCE OF THE "DESIGN-BUILD" ESTIMATE IN THE DECISION-MAKING PROCESS OF CONSTRUCTION PROJECT MANAGEMENT

The capital cost estimate for a proposal is extremely important since its early measurement of the project cost is made at a time when early management decisions have the greatest potential impact on project performance and when resource commitments are low. The following chart indicates the importance of the capital cost estimate at the early stage of a project (Fig. 6).

Thus, early decisions have the greatest potential impact on project performance and total cost, and are made at a time when resource commitments are low. Management's power to effect project economy drastically decreases as the project moves into design and construction stages.

The cost of making changes to a project will increase dramatically when resource-commitment is high (Fig. 7).

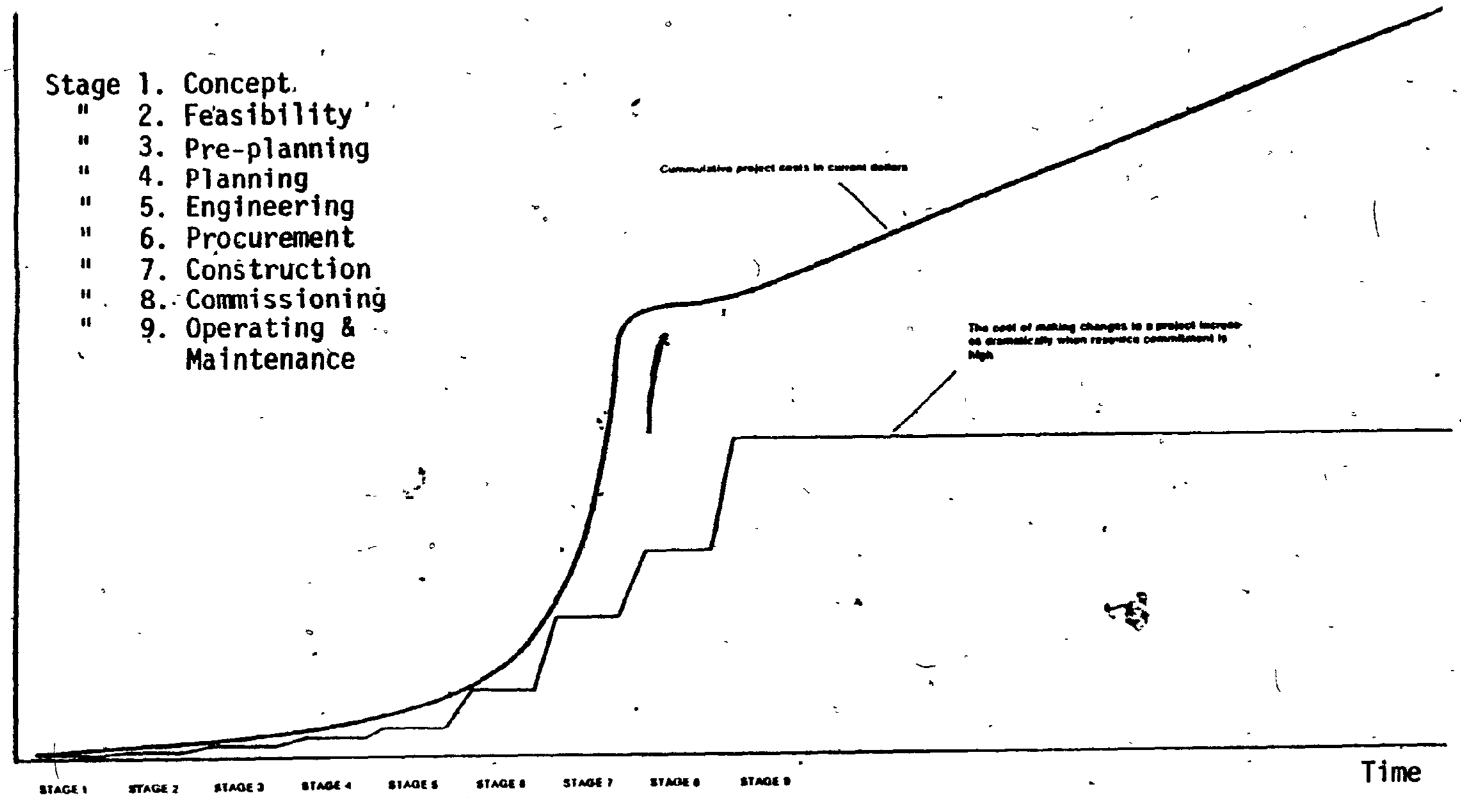


Fig. 6 Decision and Cost Implication [18]

(From - Project Delivery System - Public Works of Canada, Ottawa 1978).

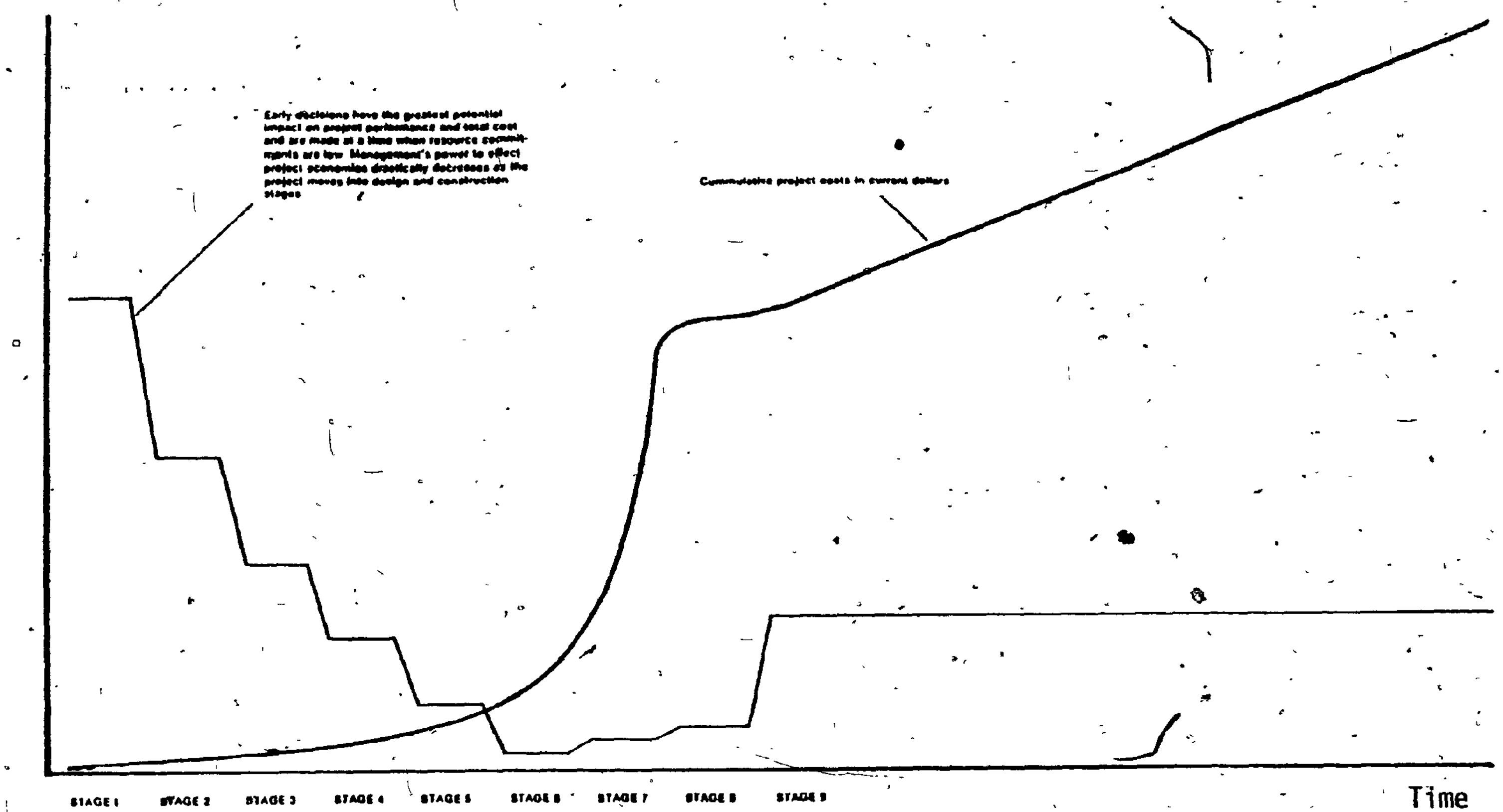


Fig. 7 Project Changes and Cost Implications [18]

(From - Project Delivery System - Public Works of Canada, Ottawa 1978).

Figures 6 and 7 are schematics only and no attempt has been made to show relative orders of magnitude of expenditure in each phase.

2.3 THE ROLE OF ESTIMATING FUNCTION IN A PROJECT PROPOSAL TEAM

In a project proposal team, i.e., a project team whose function is to prepare a design-build proposal to present to the client, the role of the estimating function is to ensure that the Project Manager and other team members are provided with a consistent and efficient estimating service for the planning and control of cost during the initial management of projects.

A typical company's proposal team and its interaction with the estimating function is shown as follows:

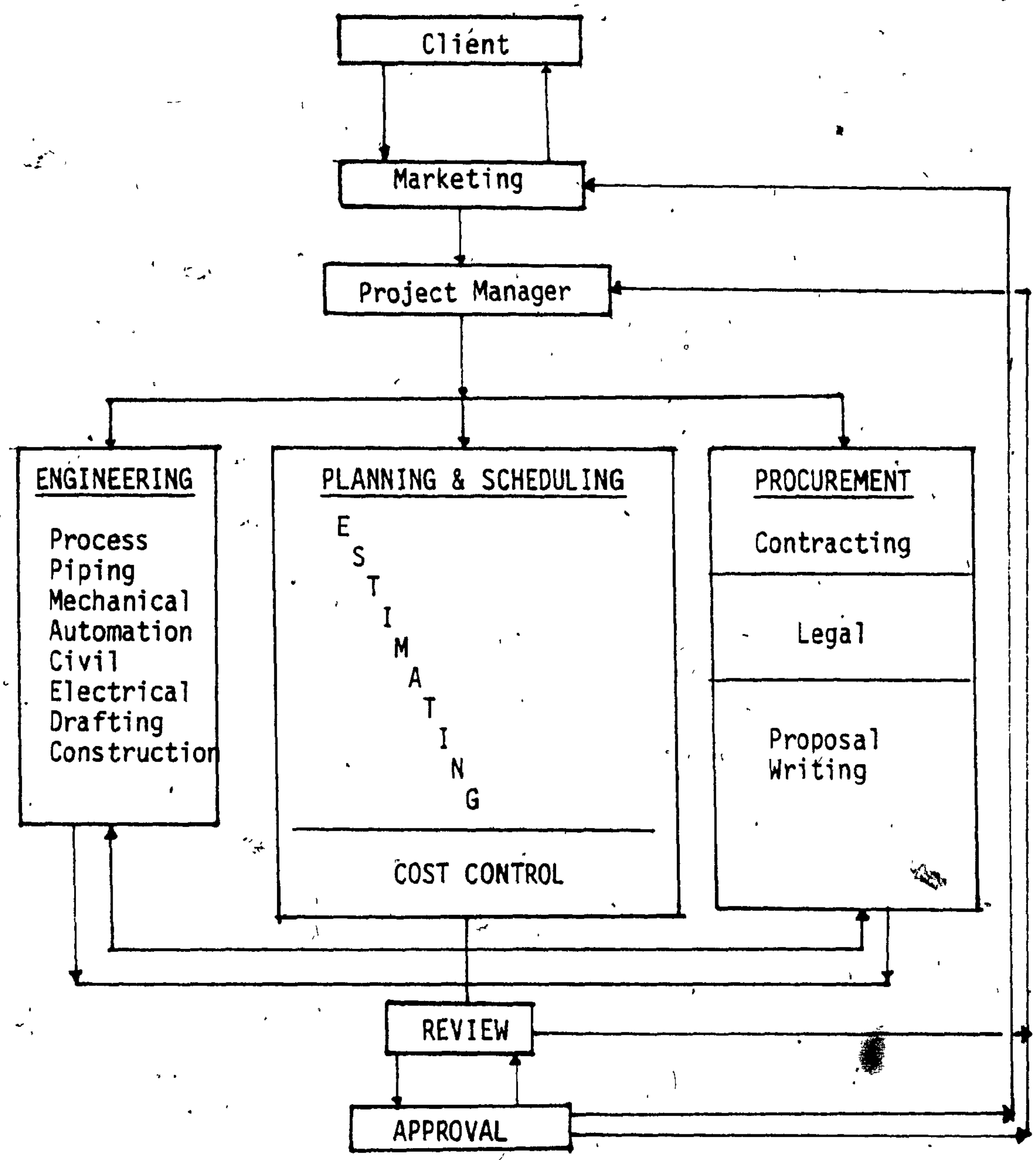


Fig. 8 Estimating Function of a Project Proposal Team

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CAPITAL COST ESTIMATE FOR INTERNATIONAL HEAVY INDUSTRIAL PLANTS

3.1 CLASSIFICATION OF HEAVY INDUSTRIAL PROJECTS

The objectives of this chapter are:

(i) To classify different types of heavy industrial projects studied in this report.

(ii) Identify important factors which must be taken into consideration in estimating capital cost of an international project.

(iii) Describe capital cost estimating approaches with respect to:

- Mineral Processing Plants
- Chemical/Petrochemical Processing Plants
- Pulp and Paper Plant
- Nuclear Power Plant

The demands of a growing industrial base, the need for improved public utilities for technology-oriented industries, the enormous wealth and poverty created in the aftermath of the oil crisis and perhaps even the desire for the luxuries of the modern era have all contributed to the growth of international projects in recent years, particularly in the developing Third World countries. Canadian engineering firms, with their North American technological expertise, have increased their efforts to win foreign business. Two factors which contribute to their exceptional effort in overseas business are:

- Firstly, a slow-down in domestic activities. Declining prospects at home have resulted in engineering firms seeking foreign contracts for the first time, while others have increased their marketing efforts abroad.
- Secondly, the increase in size of consulting engineering firms, usually through acquisition or mergers, to the point where several Canadian firms or groups are now large enough to match capabilities with those of their most diversified foreign competitors.

Highly specialized engineering skills are offered by Canadian engineering firms to foreign markets depending on the stage of development of the local economy, the types of natural resources available and the priorities of local government. Table 1 and 2 indicate international business volumes of the Canadian engineering firms by industry, as well as the bulk of engineering specialization by potential clients.

	1964 $ millions	%	1977 $ million	%	Average Annual Real Rate of Growth
Forestry, etc.	4	40	34	17	12
Mining & Metallurgy	1	10	33	17	23
Power	2	20	29	15	22
Plant Process	1	10	34	17	23
Municipal	1	10	10	5	9
Other:					
Transportation		-	16	8	
Buildings			9	4	
Air & Sea			8	4	
Petroleum & Natural Gas	1	10	7 } 60	3 } 29	35
Telecommunications			6	3	
Dams & Irrigation			3	1	
Miscellaneous			11	6	

Table 1: International Billings by Industry [19]

(From "Consulting Engineering in Canada - Overview and Prospects" prepared for the Department of Industry, Trade and Commerce and the Association of Consulting Engineers of Canada by Peter Barnard Associates of Toronto in April, 1978).

Area	% Total Non-U.S. Billings*	Sector	% of Total	
Latin America	25%	Power	25%	49%
		Mining & Metallurgy	24%	
Africa	24%	Power	24%	
		Transportation	19%	49%
		Miscellaneous	16%	
Far East	16%	Power	32%	
		Mining & Metallurgy	24%	67%
		Transportation	11%	
Middle East	14%	Municipal Services	28%	
		Mining & Metallurgy	22%	61%
		Transportation	11%	
Europe	12%	Mining & Metallurgy	47%	
		Petroleum & Natural Gas	17%	
Caribbean	6%	Transportation	32%	
		Power	23%	67%
		Plant Process	12%	
Australia	3%	Forestry, etc.	75%	
		Mining & Metallurgy	12%	

Table 2: Engineering Specialization by country [19]

Of all those industries listed, this paper will examine the estimating approach towards the following plants:

*: Percentage of engineering work not to be carried out with US technology.

— Mineral Processing Plant (Mining and Metallurgy)

Plants used primarily in the processing of minerals extracted from mines. Operations of the plant may include crushing, screening, washing, flotation, mixing etc. ... and other operations customarily done at the mine site, or as part of mining activity. Development of mining properties are included. Common minerals produced in mineral processing are zinc, copper, asbestos ... etc.

— Petro-Chemical Plant (Petroleum and Natural Gas)

Plants primarily engaged in chemical processing operations producing lubricating oils, residual fuel oils and other products from crude petroleum and its fractionation products, through straight distillation of crude oil, redistillation of unfinished petroleum derivatives or other processes.

— Pulp and Paper Plant (Forestry)

Plants primarily engaged in the manufacture of pulps and basic papers from wood and other cellulose fibers. They are also used to manufacture paper and paperboard and convert these into products such as paper bags, paper boxes and envelopes.

— Nuclear Thermal Power Plant (Power)

Plants with nuclear reactors to generate the heat required for the development of commercial power generation in thermal plants. It is the CANDU reactor, which uses a natural uranium fuel with a heavy water moderator to facilitate the handling of spent fuel.

3.2 INTERNATIONAL CONSIDERATIONS IN CAPITAL COST ESTIMATE

All projects are unique and to execute them correctly requires time. Thus, differences in location, timing and technical scope will lead to many other specific differences. The capital cost estimate will serve as a tool to evaluate how this unique combination of resources and circumstances will react at some point in the future so that decisions will be made on it. Regardless of what kind of project is to be executed and where and when it is to be accomplished, the two basic principles applied for international projects are:

- The components of resources and services required to build the plant are similar for any particular type of project.
- No rules govern the way these components interact or the basis of costing at home and abroad.

Before preparing the estimate, it is necessary to have a site visit (see Appendix B) by an experienced estimator to the country concerned to meet the client, meet and select suitable local partners (consultant firm, agents, etc...), obtain cost data by talking with various local or foreign contractors who have worked in the area, obtain information on local tax laws, currency exchange regulations, work permits, guarantee bonds, local living conditions, costs of expatriate field staff, etc... Major components of an estimate which have to be analysed in terms of resources and time required are:

a) MATERIALS AND EQUIPMENT

While construction materials and equipment are very easily supplied by sub-contractors in a domestic project, nearly all of these are imported for an international project in Third World countries, i.e., refrigeration plants, vessels, generators and many other heavy equipment. Medium-sized electrical or mechanical equipment (i.e., pumps, elevators, piping and fixtures) often come from Europe or Japan. Rough materials are usually available locally (i.e., concrete aggregates, cement, ceramic tiles, and brick). The quality of fabrication and manufacturing, in many cases, is not up to standard because competition is nil. Commonplace items, such as nuts, bolts, screws and nails can be a problem. Other materials, such as plywood, formwork, expansion joint filler or form ties may not be available in the variety or quantity required. In Latin America, concrete almost certainly will not be available in ready-mix trucks from local batch plant, so one will have to be set up on site.

Material costs may vary up or down depending on circumstances (see Appendix C). Some of the usual reasons are:

- different climatic conditions, requiring different material specifications and special weather protection
- local government regulations, such as safety standards
- local social customs that require special facilities

- ability to buy from an international market, which increases competition
- use of indigeneous materials, for political or financial reasons, or because local tradesmen know how to handle them
- loss due to deterioration particularly where long and hazardous journeys are required.

Construction equipment is often of limited availability and quality, and often a large number of laborers will be used in place of a piece of equipment.

b) LABOR

Like materials, the shortage of trained labor in a foreign country is much more severe than that in a domestic project. Research on the labor market has to be done to see if the required labor for a particular job is available as well as the quality of the available labor. However, the labor situation is much more complex because many factors have to be considered, such as productivity, availability, employment regulations, normal working hours, local trade practices, government restrictions on mobility, wage rates and fringe benefits.

The productivity of labor is the most difficult factor to assess because there are so many separate causes that effect it. Firstly, the basic skill of the worker must be assessed. This depends on the training he had been given, the tools he uses, his physical aptitude and the social attitude to work. This basic skill will be modified by the man's motivation which is affected by many factors, which themselves have different relative importance in different countries. The most important of these is the quality of supervision, which is not a direct product of the location, but rather is determined by national factors.

"Yarim, manãna, demain" are some favorite expressions indicating the desire of workers to stop working until the next day in many of the Middle East and South American countries. Sleeping on the job for new employees who have never worked shifts is very common. Performing religious acts during working hours happens often, particularly in countries of Moslem religion.

Other important local factors that influence motivation are:

- employment conditions
- working conditions
- rate of pay
- climate
- work flow
- union activity and restrictive practices
- trade practices

To a certain extent, the remainder of the factors that affect labor cost are somewhat easier to evaluate, but they are all interdependent to a certain extent, e.g., in Nigeria, only minimum rates are quoted and actual wage rates vary depending on the skill and efficiency of the tradesmen. In many other countries, the really skilled work force is far smaller than would appear, and yet there are restrictions over the introduction of expatriate tradesmen (e.g., Tunisia). Some countries have such complex regulations governing the hiring of men that it is virtually impossible to hire them (e.g., India). In Columbia, fringe bebefits can equal the basic wage rate [31]. There are cases where an unskilled man has to be employed as a helper for each skilled man, in addition to the men genuinely needed for unskilled jobs (e.g., South Africa). As a result, the employment of labor adequate to complete a project on time is almost always more complicated and more expensive than would appear on initial investigation. Do not assume that local tradesmen are less efficient than our standard in North America. Specific trades in specific countries are at least as efficient as our local labor, and, in their own environment, may even be more efficient. Examples of this include Trinidian and Lebanese welders, carpenters in certain African countries, Polish brick-layers etc. Another point worth-mentioning is the danger of extrapolation from one country to another and even within one country. For example Lesotho is a small country completely surrounded by South Arica, but its condition for the employment of labor is very different. However, in general, productivity is lower than North American standards. If there is not enough trained labor available locally, plans must be set out to get this labor force in order to efficiently staff a project. Mechanical/Electrical trade personnel, which is always needed, comes mostly from Europe.

Pipe fitters, cement masons, welders and iron workers may be in short supply. However, carpenters and brick-layers are generally available in most countries.

Some specialist trade workers, such as automation technicians or lead burners, may be almost non-existent. It is frequently necessary to bring in expatriate supervisors to train the local tradesmen in specific skills. Recently, especially on Mid-East construction projects, much of the trained labor has usually come from South Korea or other Far Eastern countries. Living conditions usually are quite different because of climate and local customs. Imported labor is usually obtained through an agency, with contracts for two years or longer. To maintain good morale among the work force, recreational activities must be arranged as part of the working agreement. In addition, the higher cost of living expenses, such as housing and schooling for employees' children are included. As a result, the author believes that in order to minimise labor problems in an international project, one has to have a good knowledge of the political, cultural and social structure with respect to labor factor in foreign countries.

Thus, even though labor cost rates might be a fraction of domestic scale (see Appendix C), the labor factor in an international project is very complicated and requires careful study and investigation by an experienced estimator having good knowledge of the international scene.

c) INDIRECT COST

Indirect costs are items of cost associated with the project which cannot be conveniently charged directly to single estimating account. These costs can skyrocket on an overseas project since, for the purpose of capital cost estimate, these costs are often expressed as a percentage of the direct costs. (Materials, Equipment, Labor). Indirect costs — for transportation, communication, site services, accomodation and supervision —, include the transport to and from the site of all materials, men and supplies, the communication system as well as the planning and operation of all field services and maintenance facilities. Indirect cost can skyrocket in cases where the transporting of materials and men over 500 miles can be considered as an abnormal cost, in contrast to a domestic project for which such a problem is normal.

Thus, consideration must be taken concerning the time required to reach the site, shipping costs, trans-shipment delays, charges and dues, weight and size limitations of equipment, climatic conditions. Sometimes, roads are inadequate (e.g., extremely inadequate roads for the presently-proposed Copper Smelting and Refinery project in the area of Leyte, Phillipines) or harbors have insufficient unloading capacity causing the time required for unloading and customs clearance to be excessive. Major equipment can take six to eight months to reach the site from the works. Deliveries can be halted by climatic conditions, such as heat and rain. Red tape is hard to avoid in some countries, all materials and equipment must be packed and protected to sit on site for 18 months since no work can go ahead until all equipment and supplies have been delivered and checked. Quite often, the construction of warehouses is needed to allow for very early ordering of material and equipment in order to have them available when required. The worst situation that can happen is to have very expensive labor sitting around and waiting for material deliveries. Cement in Korea cost $50 a ton delivered on site, while in Saudi Arabia, a ton costs $140. Problems for transport of labor and staff, such as time and cost of initial and final transport, daily transport needs, government restrictions and delay especially on expatriate personnel must be taken into consideration. Communication systems, such as a daily courier system, telex system or even telephone system must be set up. The cost of adequate housing, schooling, medical facilities, transport and vacation for all expatriate staff and their families must be carefully assessed.

d) TAXES, DUTIES AND CURRENCY FLUCTUATIONS

Taxes and duties are changeable. The rates are often different for exporting countries. Thus, it should be beneficial for the engineering firm working abroad to make these rates as part of the contract.

It is also necessary to review the exchange rate fluctuations as related to the Canadian or United States dollar during the last two or three years, and naturally predict ahead as well. It is better to close an agreement in the Canadian dollar currency if the major material and equipment sources for the project are from Canada.

e) ESCALATION

Escalation is defined as the increase in costs which can be attributed mainly to inflation. Escalation will increase as the size and complexity of the project increases. To arrive at the most probable trend, a careful study of the construction activities in the area must be done. Considerations must be taken when additional labor is imported at three or four times the cost of local labor. Overtime work and shift work seldom produce acceptable productivity, due to local weather, customs or beliefs. Inflation has an important effect on escalation rate. In some countries, escalation can reach as high as 50 percent in one year. One of the past best approaches is to store historical data, plot it on graph paper and predict the trend. However, this approach seems to be less effective particularly in recent years when the rate of inflation is unpredictable.

f) LOCAL FACILITIES

The transportation system in many foreign countries is not usually up to North American standards. Railroads cover only parts of the country and, in general, trucks carry all the loads. Power supplies are poor, which leads to "start-up" problems later. Shortages of practically every item can be expected, such as food, staples, fuel, cigarettes, gasoline, tires, spare parts, water, etc... These shortages make the construction of an industrial complex extremely difficult.

g) CASH-FLOW SCHEDULE

To avoid eventual financial problems due to bad payment by the client who prefers to make only a limited number of large payments per year of the project life, a well-analysed cash-flow has to be prepared and all the important factors must be considered in the estimate, especially construction time, since international work takes much longer than domestic, and heavy equipment must be purchased early, depending on the project. A typical monthly cash-flow is widely used since it will help to predict the financial status of the project and detect possible financial problems during the construction of the project. Thus, with a cash-flow schedule, financial problems will be handled more effectively if they are not on the right track.

h) PROFIT

Profit should be estimated after taking into consideration all the risk factors effecting the capital cost of the estimate. It is, in fact, a risk-based factor. Risk analysis, as a result, must be done so that the profit can be estimated as correctly as possible. Depending on the market activity, profit can be estimated and achieved with good management.

i) Miscellaneous components

Other components of significant importance with respect to the estimate of an international job can be described as follows:

1) Growing interest in many countries to develop their own technological skills. Thus, engineering contracts will generally include a requirement to maximise the use of local sub-consultants, usually in the areas of foundation and some of the civil engineering work as well as mechanical engineering detail drafting. It is extremely important that sub-consultants' work is closely controlled by Canadian technical staff. This interest reflects one aspect of the feeling of nationalism existing in all countries. That is clients in developing countries do not want to just watch North American technology and experience create a new plant or factory for them. They want to participate in the project, learn the management techniques, and feel the satisfaction of knowing that it is their project accomplished by their local forces and that they have developed new capabilities in the process of doing the project.

2) Planning techniques used in North America may not be appropriate. It has been found impractical if a computerized CPM system is to be used and the necessary hardware and soft-ware is not available in the foreign country forcing up-dating information to be sent back to Canada each time.

3) A basis for the division of costs into local and offshore categories must be drawn up. This division of work applies to dollar budgets, as well as the local currency budget and it must be established

before pricing the proposal.

4) Most countries in the Third World have central planning committees who determine on a macro scale what is to be built. (e.g., Algeria, Tunisia, Turkey, Chile, Peru, Ecuador, Yugoslavia, Egypt). So, the reaction toward foreign firms and technology of these central planning committees must be observed before seriously bidding for any project.

5) Training for local employees who will operate the plants will take longer than the recommended period suggested by the client. Sometimes, these employees must be sent to a foreign country for "on-the-job" training in a plant similar to the one they will operate.

6) A familiarity of local customs and culture is a must. (e.g., social structure, local customs, local laws, local ethnic groups, social aspects, driving habits, food, religion, acceptance of women, calendars, holidays, etc.)

7) The governing language of the contract, i.e., whether or not the foreign language is the one that governs the contracting document's content.

Allowance for expatriate personnel and their families, such as salary premium, hardship allowance, living allowance, automobiles, relocation cost, passports, visas, work permits, medical and psychological testing, furniture, education for children, personal taxes, additional leave benefits, compassionate leave, emergency evacuation, etc.

In conclusion, only by having these above-mentioned factors considered can we arrive at a confident and accurate estimate in the international scene. It is possible that there might be other factors affecting the international estimate as time and situation change. However, those discussed above are believed to be the basic and the most important ones for an international capital cost estimate. Appendix B is also used as a guide check list in collecting information required to prepare a reasonably accurate estimate of the capital cost of an international project.

3.3 INTERNATIONAL CAPITAL COST ESTIMATE

3.3.1 BASIS OF PROPOSAL-TYPE ESTIMATE

Purpose: To prepare a capital cost estimate to be presented to an international industrial corporation in a lump-sum contract. The estimate should be considered as a preliminary estimate to be used for the purpose of appropriation for expenditure of capital funds and the award of engineering services.

Information availability:

i) Plant location and site conditions: General information on soil, access to site, local weather, labor force, economic situation, wages, cost of raw materials, etc.

ii) Plant size and its products: The capacity of the plant must be well-established because this is the basis for calculating equipment and utilities. The plant's main products and by-products must be determined since some by-products may even require special process or auxiliary facilities.

iii) Process flowsheets: A set of process flow sheets is developed indicating all major and probably minor equipment; all major lines, valves, and controls, major utility requirements such as water, steam, gas or probably instrument air. Product handling and loading of the incoming raw materials must be included.

iv) Equipment sizing and plant layout: With the process flow sheets developed, process engineering can calculate flows, temperatures and pressures so that mechanical engineering can size all the process and mechanical equipment. Those calculations will form the base for equipment pricing, plant and piping layout, supports and foundation. It is very important that this equipment list is as complete as possible since other parts of the estimate will be estimated as a percentage of process equipment costs. Thus, it is important that the cost of process equipment must be as accurate as possible.

v) Material specifications: The equipment and piping specifications must be based on the process, temperatures, pressures and products to be handled. Plants that may use many different or uncommon materials cost more than conventional plants.

vi) List and size of buildings: Process buildings, shops, garages, administration buildings, hospitals, living quarters, warehouses, whichever required, must be listed with their sizes.

vii) Information of "in-house" past projects.

Accuracy of the estimate: The accuracy of the estimate will be in the range of ±10% to ±15%. It is worthwhile to mention that the accuracy of the estimate predicted is a useful indicator for management people to arrive at the firm-price charged to the client. The firm-price must be defined after taking careful consideration of contingency and escalation allowances. The accuracy of the estimate, however, is not intended to arrive at an extra charge at a later date towards the client if the capital cost of the plant is overestimated.

In other words, the engineering company which bids for the "firm-price" contract will have to perform the work as described by the contract under the guaranteed firm-price regardless of the final outcome of the cost to build the plant.

3.3.2 CAPITAL COST ESTIMATE

Capital cost estimating for an international project proposal presented here will enable engineers to rapidly assemble a wide variety of reasonably good cost estimates in order to arrive at the cost of a future installed plant, recognizing that there are fluctuations and uncertainties in conceptual work due to a minimum of design information. Purchasing is to be done on a world-wide basis many months or years in the future and labor cost must be estimated for a remote foreign area.

3.3.2.1 PROCESS EQUIPMENT (INCLUDING MATERIALS)

The base for the estimating procedures is the cost of major pieces of process equipment. Once the major pieces of this equipment have been defined, the estimate will be proceeded with for cost information. There are two types of process equipment:

– Major process equipment: Equipment in which process materials undergo a change of state, condition or composition; or equipment in which process material is stored, e.g., circulation pumps, container fabricating equipment, furnaces, silos and storage tanks, water treatment equipment, paper machine, rewinder, etc.

– Auxiliary process equipment: Equipment associated with major process equipment for material movement, instrumentation, process control and electrical control, e.g., blowers, control valves, conveyors, instruments and controls, pumps, vibrating feeders, motor control centers, overhead cranes, weighing devices, etc.

The best source is to obtain quotations from the suppliers of the equipment required. Quotations are also requested from some potential suppliers on a competitive basis from certain developing countries. These sub-contractors will give equipment prices as accurately as possible with details concerning firm prices, escalation clauses, delivery time, etc. These equipment prices will be verified and checked by the purchasing, engineering and estimating departments with respect to their quality and costs. Effective cross-checking can be done through an "in-house" retrieval system containing past-project equipment costs. For equipment which is not quoted by suppliers, its prices can be obtained from the files of past purchase orders from previous jobs which may be present in the Purchasing or Procurement Department. These prices must be corrected to the current cost index. A common price adjustment practice, obtained from July/August 1977 publication of The American Association of Cost Engineers (AACE), is suggested for price adjustment in the light of changes in labor and material price indices. These price changes occurred after the date of the original quotation in some European countries, USA, Japan and South Africa (see Appendix D). For common types of process equipment, such as tanks, pumps, heat exchangers, crushers, boilers, etc., the capacity and cost of homogeneous items of equipment are often related in the form:

$$\text{COST RATIO} = (\text{SIZE RATIO})^f$$

where the exponent of "f" is a factor ranging usually from 0.5 to 0.8 for process equipment. A typical list of capacity-cost exponents of process equipment is shown in the table 3. For additional exponent values, see Appendix E. Judgment, based on years of experience, should be exercised in selecting an exponent that suits the situation.

Equipment Description	Capacity or Size	Exponent / Range
Blowers: centrifugal/motor	to 10 hp	0.15-0 40
	15-500 hp	0 60-0 90
Blower: axial/motor	to 5 m, cfm	0 12-0.35
	to 15 m, cfm	0 30-0.40
	to 50 m, cfm	0.50-0.75
Boilers. package	to 4 m, lbs/hr	0.90-0.98
	to 15 m, lbs/hr	0.65-0.80
	to 50 m, lbs/hr	0 40-0.75
waste heat	to 5 m, lbs/hr	0.88-0 93
	to 25 m, lbs/hr	0 60-0 75
Compressors: centrifugal		
Motor drive	to 100 hp	0.90-1 25
Steam turbine drive	to 2000 hp	0 30-0 70
Turbo, 3500 rpm		
Process service	500-2000 hp	0.60-0 80
Compressors. reciprocating		
Motor drive, air	to 500 hp	0 80-0.95
	to 5000 hp	0.65-0.80
Motor drive, process	to 100 hp	0.70-0 90
	to 1500 hp	0 80-0.95
Gas engine drive		0 80-0 90
Compressors: rotary		
Motor drive	to 500 hp	0 60-0 70
Dust collectors. bag filter (only)		
Shaking type	to 10 m, cfm	0 50-0 65
Light duty	to 40 m, cfm	0 90-1.0
Heavy duty	to 20 m, cfm	0 80-0 95
Dust collectors. centrifugal		
Impeller, includes hopper, only		
Dry type	to 20 m, cfm	0.60-0 70
	to 75 m, cfm	0 80-1.0
Wet type	to 20 m, cfm	0 70-0.80
	to 75 m, cfm	0.80-1.0
Dust collectors: cyclone		
No frame and mounting		
Light duty	to 10 m, cfm	0.4-0 6
	to 20 m, cfm	0.80-1.0
Heavy duty	to 10 m, cfm	0.60-0.80
	to 40 m, cfm	0 90-1.0
Electrostatic precipitator		
Automatic		
Range of all types	to 100 m, cfm	0 60-0.90
	to 200 m, cfm	0.65-0.90
	to 500 m, cfm	0.30-0.85
Scrubber, water spray		
Light	to 20 m, cfm	0.60-0 85
Heavy	to 30 m, cfm	0.60-0.85
	to 50 m, cfm	0 80-0.95
Ejectors, range, single, C.I.	to 2m, cfm	0.45-0.80
Ejectors, four stage, C I.		
Barometric type, air	to 80 cfm	0.40-0.60
Surface type, air	to 80 cfm	0 45-0.65
Filters, plate and frame		
CI, alum., PVC, rubber	to 650 sq. ft.	0.55-0.70
stainless	to 450 sq. ft.	0.80-0.90
Heat exchangers, kettle type		
U-tube, 150 psi, c.s.	to 10 m, sq. ft.	0.45-0.60
	to 20 m, sq. ft	0.60-0.70
	to 4 m, sq. ft	0.60-0.75
Floating heat, 150 psi, c s	to 600 sq. ft.	0 30-0.50
	to 2 m, sq ft	0 55-0.75
300 psi, c s.	to 600 sq. ft.	0.35-0.55
	to 2 m, sq. ft	0 50-0.75
Heat exchangers. shell and tube		
Fixed T S , c s , 150 psi,		
c.s tubes	to 400 sq. ft	0.50-0.60
	to 2000 sq ft.	0 65-0.85
s.s tubes	to 300 sq ft.	0 60-0 75
Floating head, 150 psi,		
Adm. tubes	to 400 sq ft	0 60[illegible]
	to 2000 sq. ft.	0.80-[illegible]
c s tubes	to 400 sq. ft	0.55-0.70
	to 2000 sq ft.	0.75-0.90
U-tube, remove bundle,		
c.s shell, 150 psi,		
Adm tubes	to 1000 sq ft.	0 75-0.90
c.s tubes	to 1000 sq ft.	0 65-0.85
s.s. tubes	to 1000 sq ft.	0.80-1 0
Kettles, cast iron, jacketed,		
100 psi	to 800 gal	0.30-0 40
	to 2500 gal.	0.40-0.60
Glass lined, jacketed	to 800 gal	0 35-0 45
	to 2500 gal	0.55-0 75
Mixer, agitator		
Propeller or turbine type		
with motor, s.s	to 10 hp	0.75-0.85
	to 20 hp	0.50-0.70
	to 30 hp	0.20-0.35
Side entering, w/motor		
Gear drive, c.s	to 25 hp	0.40-0.60
Gear drive, s.s	to 25 hp	0.40-0.65
Motors: induction, 440 V.,		
Exp. proof	to 20 hp	0 60-0.85
1800 rpm, 60 cy., 3-ph.	to 200 hp	0 80-0.95
Open drip-pr.	to 20 hp	0.60-0.75
	to 200 hp	0.80-1.0
TEFC	to 20 hp	0.55-0 65
	to 200	0.85-1 0
Motors. induction, 2300 v ,		
exp.-proof, open drip-pr ,		
TEFC	250-500 hp	0 65-0.85
Vessels		
Flat head		
Carbon steel	to 1500 gal.	0 65-0 85
c s glass lined	to 1000 gal.	0.40-0.60
c.s., jacketed	to 1500 gal	0.65-0 80
stainless steel	to 1000 gal.	0.65-0.85

Note: M = 1000; c.s. = carbon steel; s.s. = stainless steel.

Table 3: Selected Cost Capacity Equipment Exponent Ranges for Cost Estimating [1]

Cost indices to capacity-cost relations can be used to estimate current prices of equipment from obsolete prices. A cost index is the ratio of costs at a particular time to costs at a specified base year. Where the price of an item at some time in the past is known, the current price is estimated from:

$$\text{PRESENT COST} = (\text{COST IN THE PAST}) \frac{(\text{COST INDEX NOW})}{(\text{COST INDEX IN THE PAST})}$$

Cost indices are based on mean costs over a period of time. They have an accuracy of ±10 percent and they are used with equal to or better than this accuracy when the time lapse is less than ten years [5].

Of the various cost indices available, the following are commonly employed in the process industry: (1) Engineering News-Record construction index (ENR), (2) Marshall and Stevens cost index (M & S), (3) Chemical Engineering plant construction cost index (CE), and (4) Nelson Refinery construction cost index (NR). Each index is based on specific information suitable for its purpose [1].

Current values of cost indices and other economic indicators are published in various journals, such as Chemical Engineering, Oil and Gas Journal, Engineering News-Record. Table 4 and 5 list the ENR, M &S and CE cost index values for the year 1976 and the period from 1950 to 1975.

Month	ENR Construction Index	M & S	CE
Average	2400	472	192
Jan	2300	-	187
Feb	2310	458	188
Mar	2317	-	188
Apr	2327	-	189
May	2357	469	190
June	2410	-	192
July	2414	-	193
Aug	2445	477	194
Sept	2468	-	196
Oct	2478	-	196
Nov	2486	485	197
Dec	2490	-	198
Base Year	1913=100	1926=100	1957-50=100

Table 4: Cost Index Values for Year 1976 [5]

Year	ENR Index	M&S (All-Industry)	M&S (Min/Milling)	CE Index
1950	510	168	171	74
1951	543	180	181	80
1952	569	181	182	81
1953	600	183	184	85
1954	628	185	187	86
1955	660	191	193	88
1956	692	209	216	94
1957	724	225	228	99
1958	759	229	234	100
1959	797	235	237	102
1960	824	238	241	102
1961	847	237	239	102
1962	872	239	240	102
1963	901	239	240	102
1964	936	242	243	103
1965	971	245	245	104
1966	1019	253	253	107
1967	1070	263	264	110
1968	1154	273	273	115
1969	1270	285	286	119
1970	1380	303	303	126
1971	1571	321	321	132
1972	1726	332	332	137
1973	1897	344	343	144
1974	2019	398	394	165
1975	2209	444	451	182

Table 5: Cost Index Values from 1950 to 1975 [5]

Example: Find the cost in July 1973 of a 3,500 lb/hr steam boiler. A comparable boiler, having a capacity of 5,500 lb/hr cost $10,560 in July 1966.

ENR construction cost index for July 1973 was 1924, while for July 1966 was 1050. Hence, cost of 5,500 lb/hr boiler in July 1973 becomes:

$$\frac{(1924)}{(1050)} \times \$10.560 = 19,350$$

Capacity rate: $\frac{3,500}{5,500} = 0.636$

Assume: Capacity cost exponent = 0.6

Cost ratio = $(0:636)^{0.6} = 0.762$

Estimated cost in July 1973 of 3,500 lb/hr steam boiler is

$$0.762 \times \$19,350 = \$14,750$$

Another method of estimating equipment cost is to use the equipment cost curves developed by maintaining a private collection of cost data and from these correlations arriving at cost charts.

Appropriate cost escalation must be applied to suit the time of use of the data and, if applicable, taxes, crating, freight must be added. Great care must be exercised to examine the age, applicability, completeness and accuracy of the data before it is used. Appendix F will give typical cost curves from Marshall and Stevens. This collection of cost data includes many items used to make preliminary plant cost estimates.

3.3.2.2. LABOR

This part of the project cost must be considered very carefully, for it may completely change the profitability of the entire project. Information on productivity-manpower availability, union influence of the country concerned, other contracts in the area, availability of general and specialized contractors and distance from the labor source must be obtained.

Labor costs, especially for installation of equipment and piping, are subject to considerable variation and cannot be determined with the same degree of accuracy as material cost. Thus, labor costs represent the largest element of risk associated with the project.

Low productivity, overtime work, wage rate increases, and labor disputes during the period of construction may have a disturbing effect on labor estimate. The basis of estimating labor cost is the amount of labor-hours required to perform the work, i.e., the evaluation of manhour production is of great importance. At this stage of the project, where there are many unknown factors, particularly for a foreign project in a remote site of another country, it is better to evaluate the amount of work that a man can produce per hour on an average basis, including periods of both peak and minimum performances. This basic productivity is measured in the form of units such as "Manhours per Ton of Equipment" or "Manhours per linear foot of pipe" or "Manhours per Buttweld", etc. The sources of information for evaluation of the basic productivity can be summarized as follows:

- Personal field experience
- Actual labor cost and production reports
- Estimating handbooks, manuals and other publications such as Page, Means publications
- Tables and diagrams developed from historical data of projects executed in the past.

As the conditions surrounding the work influence the productivity (in fact, productivity must be measured while it is happening), the basic manhours must be adjusted for productivity. Judgment and personal experience must be used to consider all factors affecting the efficiency. Most of these factors can be judged based on the site visit mentioned earlier. Some of the factors are:

i) Job schedule and overtime requirement (the longer the hours, the more scheduled work time lost through absenteeism. Injuries are also increased as hours are increased, not only in absolute numbers, but also in the rate of incidence. Experience has proved that over a prolonged period, 6 to 8 weeks or more, crews working 60 hours per week produce less work than those working 40 hours per week, i.e., 20 hours of double time is expended with a resultant reduced productivity [20]).

ii) Local weather conditions

iii) Remoteness of project, and living conditions

iv) Anticipated experience and skill of work force, based upon evaluation of resources available in the area from which labor will be recruited.

v) Method of construction, complexity of work

vi) Field supervision, working facilities, access to work

vii) Current labor relations in the area

Moreover, the following "field-labor" factors must be borne in mind:

i) Labor in the civil trades is generally predictable in terms of productivity. However, for the hard-trades - millwrights, pipefitters, electricians and instrumentation specialists - it is difficult to have a reasonable accurate productivity measurement [21].

ii) Sometimes, where union regulation permit, plant production cutbacks make it desirable to use operating personnel for construction work. These men are good at their own jobs, but inexperienced in construction work thus requiring additional manhours.

iii) Variation in output may be expected in different sections of the world. Construction worker output in larger cities tends to be low. Some variations are due to a current temporary tightness of the labor market. During boom times, inexperienced workers are hired because nothing better is available [6].

iv) Willingness to work of labor force as affected by job traditions and union rules.

A study of the most recently completed project is the best source of information to estimate the labor cost in any specific country involved. The following study illustrate this concept.

* BUILDING

	Rust	Argentina	Productivity Factor (Used North American as a basis)
Earthwork	4438	12454	.36
Concrete	41684	84955	.44
Struct/Steel	26809	80585	.33
Architectural Works (glazing, floor finishing, etc.)	11294	29514	.38
Sub Total	84255	207508	.39

* PROCESS EQUIPMENT

	Rust	Argentina	Productivity Factor (Used North American as a basis)
Agitator	39.3	75	.53
Pumps	44.2	90.4	.49
Screw Conveyors			
12"	92	187.9	.49
20"	92	347.9	.26
Bucket Elevator	245	480	.51
Open Belt Conveyor			
18"	825	1156	.71
30"	1028	1650	.63
Fans	40.2	87.8	.46
Heavy Process Equipment	35	58	.61
Tanks	43	68.5	.63
Washers	35	91	.38
Process Equip. Average			.52

* PIPING

	Rust	Average in Argentina	Productivity Factor
Carbon Steel	147340	169380	
Stainless Steel	226200	324500	
Sub Total	373540	493880	.76

* ELECTRICAL

Electrical Motor	.71
Deleted	-
Cables	.87
Wire Pulling	.63
Galvanised Conduit Rigid	.52
Industrial Fixture	.36
Cable Tray	.80
	.60

* INSTRUMENTATION

C. S. Piping	.67
Trans Tubing	.87
Cable Tray	1.09
Temperature Type	.65
Level Type	.50
Flow Type	.48
Pressure	.38
Misc.	.50
Panel B. D. (Deleted)	-
Running Multitube Mounting & Connecting (Deleted)	-
Transmitter	.28
TRC	.42
Panel Mounted	.85
Average for a Total Job per Equipment	.40
Average	.51

Table 6: Installation Manhours Comparison Study Argentinian v/s North American (A study completed in December 1978 by Rust Engineering Co. Birmingham, Alabama USA)

Productivity Factor per Discipline

Civil	.39
Process Equipment	.52
Piping	.76
Electrical	.60
Instrumentation	.51

Table 7: Installation Manhour Comparison Study Summary. Argentinian v/s North American

The productivity factor in this study represents the relative installation manhour performance of an average Argentinian to that of a standard North America worker in the same trade. It is reported in "real-time" terms to perform a similar specific task.

3.3.2.3 INDIRECT COSTS

The two major categories of total project cost are the direct costs (Equipment, Materials and Labor) and all other costs which are identified in this paper as indirect costs.

There are many items of cost associated with any construction project, which cannot be conviently charged directly to a single estimating account. These items are commonly referred to as indirect costs. The indirect cost accounts include indirect construction costs, professional services, client's and other charges, contingency reserve and escalation cost. For the purpose of the proposal-type estimate, these items are expressed as a percentage of the direct cost. (When detailed construction cost estimates are produced later in the project period, many of these items can be priced out individually. However, they are still considered indirect because of their multi-purpose nature). Indirect field construction costs include facilities, equipment and services required to directly support the construction operations. The following items must be considered and included:

Indirect Construction Cost

i) Field office and labor expense includes the cost of providing the field office building, furnishing and equipping it with office equipment. This also includes the field office operating expense, such as janitorial service, utility services, stationary supplies and reproduction costs, as well as communication costs. The costs associated with the employment of safety equipment, labor administrative costs are also included in this category of indirect construction cost. If the project is at an isolated site requiring a construction camp, the costs of developing and operating the camp would be included here.

ii) Non-manual labor costs, such as wages and benefits for inspectors and technicians, clerks, typists, draftsmen, timekeepers, messengers and such other field personnel who are usually locally hired. Construction management personnel are not included here.

iii) Cost of temporary construction buildings which includes change buildings, warehouses, workshops and assembly building, toilet buildings and all trailers and buildings used by service engineers.

iv) Cost of construction tools and equipment includes the cost of procuring and maintaining heavy equipment, automotive equipment, and special equipment rentals as required. The source of supply of such equipment is not considered significant for estimating purposes and could be client-furnished, or leased or furnished by contractors working on the job. The cost of small tools is also included, although these are usually furnished by the contractors who are responsible for controlling their use. Specialty equipment required for equipment intensive work, such as piledriving and earthwork, is included in the direct cost section of the estimate.

v) Temporary facilities include the installation of temporary utility distribution systems (water, air, gas, sanitation, electricity, etc.) and temporary transport facilities, such as roads, railroads and parking areas. Special provisions for inclement weather protection, including enclosures and services (heat, light, etc.) are also included.

vi) Expendable supplies includes charges for utility services, fuels, oils, and lubricants used during construction. Gas and chemicals are also included in this category.

vii) Construction service costs such as testing laboratories and surveying, security services, toilet rentals, trash disposal.

viii) Premium payments for time not worked such as inclement weather, show up time, paid holidays, paid absences, sick leaves and allowances for lost time due to labor disruptions.

ix) Cost of insurance and bonds includes the premium paid for all risk, builder risk coverage, public liability and property damage bid and performance bonds.

Professional services

Professional services include the following activities: Project management, preliminary engineering, detail engineering and design, construction management, procurement services, architectural design, shop inspection and expediting.

Client's and other charges

Charges include general office expenses, client's field staff, legal fees and capitalized start-up cost, spare parts and special tools for operation and maintenance of the completed project.

Contingency

Allowance for costs which may be incurred as a result of factors which cannot be specifically anticipated and, thus, cannot be included in the direct account. Items such as unknown site conditions, unforeseen construction problems, engineering uncertainty and variances in labor productivity are included. In recent years, it has also been necessary to consider the effects of an uncertain and rapidly changing economy. Contingency does not include "force majeure" or major scope changes.

Escalation

The cost of major international projects of long duration is affected greatly by the country's economic conditions. Therefore, the project estimate must be prepared for the current year and the cost must be escalated to meet the project schedule.

3.3.2.4 CAPITAL COST BREAKDOWN COMPONENTS

The capital cost estimate will be based on the following cost breakdown components:

PROCESS EQUIPMENT

- All process and production equipment - material handling, vessels, tanks, thickeners, crushing, grinding, flotation, electric motors and drive components.
- Mobile, shop and maintenance equipment, cranes, pumps, etc. laboratory and testing equipment should be included.

All costs of local freight to plant site are included (ocean freight and incidental cost is a separate, individual cost addition).

EQUIPMENT INSTALLATION

Cost of all labor, construction materials and supplies, as well as construction equipment required to install the above-mentioned process equipment.

PROCESS PIPING

Cost of all piping fittings, valves required for the operation of piping and process equipment - labor, materials, construction equipment scaffolds, pipe insulation and covering. Cost of service piping - such as building heating, potable water, drainage - is not in the category of process piping.

ELECTRICAL

Cost of all major incoming power switchgear and transformers, high voltage and low voltage distribution duct banks, unit substations, power wiring and motor control centres for all piping and process equipment - including all labor and installation cost.

Building lighting is included in various categories of building structures - not in electrical component.

INSTRUMENTATION

Cost of all instrument control valves, computer installation for process control whether it is electrical or pneumatic operation, including all cabling, cable tray and installation labor.

PROCESS BUILDINGS

Complete erected-cost of all buildings and structures to house or support process and production equipment, including all foundations, super-structure, interior finish, plumbing, heating, ventilation and lighting.

AUXILIARY BUILDINGS

Erected costs of all administration and service buildings, warehouses, maintenance shops, pump houses, boiler and compressor houses (excluding equipment).

PLANT SERVICES

Installed cost of service-systems, such as water supply and distribution - potable fresh and salt water cooling, fire protection, storm and sanitary drainage, effluent treatment and disposal, compressed air supply and distribution, steam plant and distribution piping including condensate return.

SITE IMPROVEMENT

Cost of all site grading, fencing, in-plant road systems, in-plant rail lines, yard lighting, landscaping, parking areas.

FIELD CONSTRUCTION INDIRECT (FIELD EXPENSES)

Costs of all field expenses related to construction management, not directly chargeable to a specific account, include such costs as:

- Cost for temporary water, power, sanitation and heating
- Supply and maintenance costs for job duration
- Temporary offices, warehousing, etc...
- Guards and watchmen
- Job clean up and bulk material handling
- Insurance, bonds, taxes, etc.
- "On-site" or Field Office Job Management
- Small Tools and Equipment Rentals
- Cost of client's field staff, legal fees, etc.

PROJECT MANAGEMENT (Including Engineering, Construction Management)

Costs for the following:

- ENGINEERING: includes basic and final engineering
- PROJECT MANAGEMENT: includes Estimating, Planning and Scheduling, Cost Control, Procurement
- CONSTRUCTION MANAGEMENT: Construction supervision, including co-ordination with two previous disciplines.

The following tables indicate the plant component cost ratio method for various types of heavy industrial plants.

3.3.2.4 A MINERAL PROCESSING PLANT

PLANT COMPONENTS	% OF TOTAL PROJECT COST	RELATIVE COST TO EQUIPMENT
EQUIPMENT	30-40%	1.00
EQUIPMENT INSTALLATION	5-9%	0.17-0.23
PROCESS PIPING	2-10%	0.07-0.25
ELECTRICAL	4-10%	0.13-0.25
INSTRUMENTATION	1-5%	0.03-0.12
PROCESS BUILDINGS	10-20%	0.33-0.50
AUXILIARY BUILDINGS	2-6%	0.07-0.15
PLANT SERVICES	2-6%	0.07-0.15
SITE IMPROVEMENTS	1-7%	0.03-0.18
FIELD EXPENSES	3-5%	0.10-0.12
PROJECT MANAGEMENT	9-13%	0.30-0.33
TOTAL	100%	2.30-3.28

Table 8: Mineral Processing Plant Component Cost Ratios [22]

NOTE: Adjust to suite the special conditions applying to each of the components as they may be known at the time of the study.

Table 9 tabulates typical percentages of total cost and plant component relative cost to equipment of different types of Mineral Processing Plants. These figures are developed and averaged from past studies and actual project cost records of Montreal-based

S.N.C. Group. Great care has been taken to ensure that the work included under each component was identical in each case.

The wide variance between the range of results obtained in component costs of asbestos projects compared to cement plant or zinc refining or copper refining projects emphasizes the importance of classifying projects by types of process. It is observed that individual percentages of components in each group shows a general relationship that can be useful in the early stages of a project.

Equipment costs are approximately from 30% to 40%, equipment installation costs range between 6% and 9%. In the case of cement plants, an additional component has been added to identify the cost of silos which are of significant magnitude, although silos must be considered as pieces of process equipment. This is the reason why the percentage of equipment cost of cement plants seems to be low in comparison with the others.

PLANT / COMPONENT	ASBESTOS PLANT		CEMENT PLANT		ZINC PLANT		COPPER REEF PLANT	
	% of Total Cost	Relative cost to Equipment	% of Total Cost	Relative cost to Equipment	% of Total Cost	Relative cost to Equipment	% of Total Cost	Relative cost to Equipment
EQUIPMENT	41.3%	1.00	30.0%	1.00	44.0%	1.00	31.0%	1.00
EQUIPMENT INSTALLATION	8.8%	0.22	7.6%	0.25	9.1%	0.21	5.8%	0.19
SILOS	-	-	10.5%	0.35	-	-	-	-
PROCESS PIPING	2.2%	0.05	1.9%	0.06	1.5%	0.03	5.3%	0.17
ELECTRICAL	8.2%	0.20	5.5%	0.18	4.5%	0.10	9.8%	0.32
INSTRUMENTATION	2.5%	0.06	4.3%	0.14	1.2%	0.03	3.5%	0.11
PROCESS BUILING	15.1%	0.37	13.4%	0.45	15.0%	0.34	19.5%	0.62
AUXILIARY BUILDING	2.9%	0.07	4.0%	0.13	4.5%	0.10	2.9%	0.09
PLANT SERVICES	2.2%	0.05	3.1%	0.10	4.2%	0.09	4.8%	0.15
SITE IMPROVEMENTS	1.0%	0.02	5.4%	0.18	3.0%	0.07	3.9%	0.13
FIELD EXPENSES	5.2%	0.13	3.6%	0.13	3.0%	0.07	2.9%	0.09
PROJECT MANAGEMENT	10.6%	0.26	10.7%	0.36	10.0%	0.24	10.6%	0.37
TOTAL	100%	2.43	100%	3.33	100%	2.28	100%	3.24

Table 9: Mineral Processing Plant Component Cost Ratios [22]

3.3.2.4. B CHEMICAL/PETROCHEMICAL PROCESSING PLANT

		U.K. = 1.0	U.S. = 1.0
Australia		1.4	1.3
Austria		1.1	1.0
Belgium		1.1	1.0
Canada		1.25	1.15
Central Africa		≈2.0	≈2.0
Central America		1.1	1.0
China	(imported element)	1.2	1.1
	(indigenous element)	0.6	0.55
Denmark		1.1	1.0
Eire		0.9	0.8
Finland		1.3	1.2
France		1.05	0.95
Germany (West)		1.1	1.0
Greece		1.0	0.9
Holland		1.1	1.0
India	(imported element)	2.0	1.8
	(indigenous element)	0.7	0.65
Italy		1.0	0.9
Japan		1.0	0.9
Malaysia		0.9	0.8
Middle East		1.2	1.1
Newfoundland		1.3	1.2
New Zealand		1.4	1.3
North Africa	(imported element)	1.2	1.1
	(indigenous element)	0.8	0.75
Norway		1.2	1.1
Portugal		0.8	0.75
South Africa		1.25	1.15
South America (North)		1.5	1.35
South America (South)		2.5	2.25
Spain	(imported element)	1.3	1.2
	(indigenous element)	0.8	0.75
Sweden		1.2	1.1
Switzerland		1.2	1.1
Turkey		1.1	1.0
U.K.		1.0	0.9
U.S.		1.1	1.0
Yugoslavia		1.0	0.9

Table 10: Location Factors for Chemical Plants of Similar Function
(Chemical Engineering, Nov. 5, 1979) by A.V. Bridgwater

For Chemical/Petrochemical Process Plants, effects influencing geographical cost variation can be rationalized from results discussed with informed experts from many countries, as well as from published data. Table 10, "Location factors for chemical plants of similar function" is published in the most recent issue of Chemical Engineering. Two bases are given:

- A U.K. industrial center such as Teeside and a U.S. center such as the Gulf Coast
- Capital Cost at a new location can be obtained by multiplying the known capital cost of one location by the ratio of the location factors at the new and old location.

The table figures are approximate and do not take into account any special local factors, such as the status of the economy or politics. For typical Chemical/Petrochemical process plants, Table 11 gives its percentage distribution of cost.

The factors apply to Capital Costs of new Chemical Process Industry projects within 100 miles of a major industrial or import center, or both, in the designated country. If the new site is situated away from major industrial or import centers, over and above the 100 miles already included, a 10% increase for each 1,000 miles or part of 1,000 miles must be included in the new cost.* It is possible to allow for known special effects, such as import levies or tariff

* Bridgwater, A.V., Chemical Engineering, Nov. 5, 1979

PLANT COMPONENT	FLUIDS		FLUIDS-SOLIDS		SOLIDS	
	% of Total Cost	Relative cost to Equipment	% of Total Cost	Relative cost to Equipment	% of Total Cost	Relative cost to Equipment
EQUIPMENT	23	1.00	2.8	1.00	32.5	1.00
EQUIPMENT INSTALLATION	10	0.45	11	0.39	13	0.40
PROCESS PIPING	18	0.78	12.5	0.45	5	0.15
ELECTRICAL	3	0.13	2.5	0.09	2.5	0.08
INSTRUMENTATION	5	0.22	3	0.11	3	0.09
PROCESS BUILDING	3	0.13	2.5	0.09	2	0.07
AUXILIARY BUILDING	14	0.61	17	0.61	15	0.46
PLANT SERVICES*	7	0.31	8	0.29	7	0.22
SITE IMPROVEMENT	3.5	0.15	3.5	0.13	7.5	0.23
FIELD EXPENSES	2.5	0.11	2	0.07	2.5	0.08
PROJECT MANAGEMENT	11	0.48	10	0.36	10	0.30
TOTAL	100%	4.37	100%	3.59	100%	3.49

* Includes receiving, shipping and storage facility

Table 11: Percentage Distribution for Cost of Typical Chemical/Petrochemical Process Plant [1]

barriers, e.g., in Indian and Spain. Materials or labor that are imported cost considerably more than if these were indigenous. If their share of the project's value is known, it is possible to account proportionately for the two effects.

3.3.2.4. C PULP AND PAPER PLANT

PLANT COMPONENT	PERCENTAGE OF TOTAL COST	RELATIVE COST TO EQUIPMENT
EQUIPMENT*	37.0%	1.00
EQUIPMENT INSTALLATION	10.5%	0.28
PROCESS PIPING	9.0	0.24
ELECTRICAL	7.0	0.19
INSTRUMENTAL	3.0	0.08
PROCESS BUILDINGS	15.50	0.42
AUXILIARY BUILDINGS	Included with process building	-
PLANT SERVICES	3.50	0.09
SITE IMPROVEMENT	4.00	0.11
FIELD EXPENSES	Included with site improvement	-
PROJECT MANAGEMENT	10.50	0.28
TOTAL	100%	2.69

* Percentage of cost can go up to 50% due to highly-expensive paper machine cost.

Table 12: Percentage Distribution for Cost of Typical Pulp and Paper Plant [23]

PERCENTAGE DISTRIBUTION FOR COST OF TYPICAL NUCLEAR POWER PLANT

For a nuclear power plant, particular cost breakdown components which are widely known in the nuclear power field will be described as follows: [8]

SITE IMPROVEMENT: Same as on page 61

BUILDINGS & STRUCTURES: Complete erected cost of all buildings and structures, such as reactor building, turbine building, cooling water structures, service buildings, auxiliary service structures, as well as auxiliary structures, i.e., complete erected cost of all process and auxiliary buildings.

REACTOR, BOILERS & AUXILIARIES: Complete cost of labor, process equipment and materials required to erect reactor, moderator system, primary heat transport system, auxiliary system, fuel transfer and storage, boiler steam and water systems, as well as cost of fuel and heavy water management.

TURBINE GENERATOR & AUXILIARIES: Complete cost of labor, process equipment and materials required to erect turbine generator, condensing systems, feedwater and auxiliary systems.

ELECTRICAL SYSTEM: Cost of all major power systems, such as main station connections, standby emergency generators, primary and secondary distribution station service systems, uninterruptable power supply systems, lighting and building service systems, cable conduit and cable tray, grounding and cathodic protection, eletric power systems.

CONTROL AND INSTRUMENTATION: Cost of all control and instrumentation systems for site; buildings and structures; reactor boiler and auxiliaries; turbine generator and auxiliaries; electric power systems; control center equipment; common processes and services and safety systems.

COMMON PROCESSES AND SERVICES: Cost of all water systems; heating, cooling and ventilation; miscellaneous common services; compressed gas and vacuum services; material handling; maintenance handling; miscellaneous equipment and radioactive management.

CONSTRUCTION PLANT: Cost of construction facilities, construction equipment and inventory accounts.

PROJECT MANAGEMENT (Including Engineering, Construction Management).

Same as on page 62

3.3.2.4 D NUCLEAR POWER PLANT

PLANT COMPONENTS	PERCENTAGE OF INSTALLATION & SUBCONTRACTS	PERCENTAGE OF PROCESS EQUIPMENT
SITE AND IMPROVEMENT	3.9%	-
BUILDINGS & STRUCTURES	22.6	-
REACTORS, BOILERS & AUXILIARIES	5.6	13.3%
TURBINE GENERATOR & AUXILIARIES	1.5	8.9
ELECTRICAL SYSTEMS	2.9	3.1
CONTROL & INSTRUMENTATION	1.3	2.5
COMMON PROCESSES & SERVICES	3.6	3.6
CONSTRUCTION PLANT	3.9	-
PROJECT MANAGEMENT	23.3%	-
TOTAL	68.6%	31.4%

Table 13: Percentage Distribution of Cost of Typical Nuclear Power Plant [24].

It is noted that the percentage of Project Management Cost in Nuclear Power Plants is much higher than in other process plants because special engineering effort is required in all phases of designing, procurement, construction, compared to more simplified engineering work in conventional construction. The cost of Buildings and Structures is also high due to the higher concrete cost caused by the higher component cost of cement, sand and aggregate as well as the higher cost of formwork due to high special lumber cost.

Chapter 4

CONTINGENCIES AND ESCALATIONS IN CAPITAL COST ESTIMATE

4.1 CONTINGENCY ALLOWANCE

The objectives of this chapter are:

(i) To identify the contingency and escalation allowances which have to be taken into consideration in capital cost estimates.

(ii) To describe the nature of the roles of contingency and escalation in the preparation of the cost estimate.

(iii) To describe the methodology for estimating contingency and escalation allowances.

This is an allowance for unforeseeable elements of cost, which from the relationship of previous estimates and actual costs have been shown to be statistically likely to occur. Contingency allowance is an integral part of the estimate. It is not to be considered as a compensating factor for inaccuracy in estimating nor is it intended to cover such items as any potential change in Project Scope, Act of God, prolonged labor strike activity, labor disruptions beyond the control of the Project Manager, currency fluctuation, revision to Financing Loan Agreement, cost escalation [10].

This fund reduces project risk and should be sufficient to cover all likely unforeseen and unpredictable events, conditions and occurrences that could cost the project time and money.

Like the safety factor in design work, every estimate has to carry this contingency factor, which is looked upon differently depending upon whose point of view is being expressed:

- For the estimating department, contingency is a fund that will cover possible lack of information in estimating the capital cost of the plants concerned, and any of the hundreds of small things that can delay a project.
- For management people, contingency is money that if not spent will become profit.

Some of the typical items contingency must cover are lack of information regarding either the process or the location, corrections to erroneous assumptions or items not defined in sufficient detail in the estimating stage. A reasonable contingency, which is the right amount to take care of all unknown and unpredictable occurrences with very little to spare, is an indicator of sound engineering practice.

It is the estimator's responsibility to recognize what the known and unknown factors are, and calculate the amount of contingency based on his experience. In preparing a capital coast estimate, the estimator (or Cost Engineer) can, through misapplication of contingencies, place his company in one of two extremely poor positions.

- He might overestimate, which would result in a few deficiencies, but might keep the company out of ventures which have long-term profitability.

- He might underestimate which would have the adverse effect of placing the company in unprofitable business.

For projects in the conceptual stage of development, "soul-searching" techniques must be done to come up with appropriate numbers for contingency. The amount of contingency reflects the confidence that the estimator has in his figures or in the definition of the project. This depends on the nature of the project, and changes with time during the progress of the project. For example, projects such as hydroelectric power plants could have contingency requirements different from those of steam generating electrical plants.

4.2 CONTINGENCY ESTIMATION IN CAPITAL COST ESTIMATE

The more detailed and qualitative information that is available at the time the estimate is made, the smaller the contingency allowance may be, and vice versa.

In determining the magnitude of the contingency allowance required in a particular case, each of the main elements of the estimate should be reviewed and the degree of uncertainty evaluated to establish the appropriate allowance for each element. These individual allowances added together compromise the contingency allowance for the estimate as a whole. Determining the sensitivity of certain areas of the estimate is a must in estimating contingency allowances. For example, the contingency problems of material and labor for a process of proven technology with which we are thoroughly familiar might well be reduced to considering delivery, and future productivity. On the other hand, if the process is one in which we have no direct experience and in which technology is not readily available, the contingency would, in addition to those mentioned, contain allowances for process "know-how". A change in type of plant, aside from the question of process design proficiencies, can have similar effects on our contingency numbers, e.g., we may know from experience the material and labor mix in a plant of type A, but are forced to assume the mix for a plant of type X. The fact that type A plant estimates have the backing of proven experience, and type X does not, should suggest a closer study of our contingency rate.

Examining historical records of past projects which indicate the difference between actual costs and estimated costs (in constant dollars) provide a good indication or guide as to what contingency to use for future jobs of similar nature.

Table 14 indicates historical records of different kinds of past projects studied by the Montreal-based S.N.C. Group regarding the average difference between actual costs and estimated costs. These projects were handled during the past few years on which full responsibility of Cost Control was part of the scope of services of the S.N.C. Group. Thus, measuring was possible. However, for a factor-typed estimate at the proposal stage, a 15% to 20% contingency allowance is suggested. The cost variances were recorded and averaged for different types of contracts such as "cost-plus", "unit-cost" and "firm-price" contracts.

TYPE OF PROJECT	COST VARIANCE %	TYPE OF PROJECT	COST VARIANCE %
* NUCLEAR POWER PLANT	+3%	* EXPLOSIVES PLANT EXPANSION	+5%
* METAL FURNITURE MANUFACTURING PLANT	-9%	* NYLON INTERMEDIATES PLANTS	+4%
* SHOP EXTENSION - SHIPYARD	+10%	* CHEMICAL PLANT EXPANSIONS	+4%
* COMPUTER CENTER	-9%	* CHOCOLATE PLANT	-2%
* DISTILLERY EXTENSION	+5%	* INTERNATIONAL AIRPORT	-10%
* BAKERY EXTENSION	-10%	* POLYPROPYLENE PLANT	+11%
* CHEMICAL PROCESS PLANT	+3%	* WASTE TREATMENT PLANT	-10%
* LIGHT MANUFACTURING PLANT COMPLEX	+11%	* ASBESTOS FIBRE PLANT	-2%
* TIRE MANUFACTURING PLANT	+9%	* ZINC REFINERY	-3%
* SHOP & ADMINISTRATION BUILDING	-8%	* FERRO-ALLOY PLANT	-1%
* MULTI-STOREY OFFICE AND HOTEL COMPLEX	+1%	* AROMATICS FACILITIES	-11%
* ASBESTOS FIBRE RECOVERY PLANT	-8%	* PULP AND PAPER PLANTS	3%
* ENGINE MAINTENANCE PLANT	+1%		
* HOSPITAL	0%	OVERALL VARIANCE - 3.8%	

Table 14: Target Cost Estimate vs. Actual Construction Cost on Projects for which S.N.G. had responsibility for cost control

As a result of the study of past experience, a method of calculation of contingency allowance in which an overall percentage is applied to the based estimate is very popular [28]. Actual costs are compared against estimated costs for entire completed plants to obtain the percentage of contingency allowance required. The final percentage to be applied to the estimate is viewed in the light of "special knowledge" or the lack thereof. It must be recognized that even after the addition of the contingency allowance to the estimate, the resulting total does not represent a maximum figure but is still subject to the "plus or minus" accuracy tolerance indicated in Fig. 3.

4.3 ESCALATION ALLOWANCE

The cost for the duration of the project must be projected once the plant cost is estimated. Thus, for each new project, an escalation allowance reflecting the costs within the estimate, including contingency, when realigned from the estimate date to the center of gravity (usually the midpoint) of each activity period, must be included [10]. The forecasts of escalation will include increases in prices due to anticipated materials and labor shortages, contractor work backlog, etc., if these can be determined at the time the estimate is prepared [6].

(i) Under generally stable economic conditions, the escalation allowance refers to cost increases for the principal input components of a project. For projects of short schedules from one to three years, escalation can be forecast with relative accuracy and included where it belongs. Most labor cost increases can be predicted for two or three years into the future. Most of the equipment will be delivered within a time span where costs can be predicted rather accurately. However, for projects that take much longer, predicting escalation is more difficult because most suppliers will not quote for equipment to be delivered three or four years in the future and labor contracts may be negotiated two or three times during the life of the project.

ii) Under inflationary conditions, cost increases for the principal input components are swamped by the cumulative effect of general cost increases throughout the economies of the world. Inflation effects have a significant impact on the cost, riskiness and profitability of projects. These effects are also difficult to predict reliably since the rate of inflation has generally accelerated in recent years, and is both more rapid and more variable in the less developed countries of the world. The situation is further complicated by the fact that inflation usually affects manufacturing costs and sale price differently.

The basis of the esclation procedure is the selection of a series of escalation indices for the project, e.g., labor, concrete, lumber, energy, etc. They should be based on published indices that will be readily available throughout the course of the project. Each index can be assigned variable rates of escalation over varying periods of the expected project's duration. Where some elements of the project can not be satisfactorily associated with one of the basic indices, a composite index composed of a precisely specified mix of two or more standard indices can be incorporated. From these cost indices, escalation values of principal input components of a project can be forecast, taking into consideration all possible effects, such as local economic and political factors. The impact of economic and political factors requires special effort and judgment in forecasting an accurate escalation allowance. For example, in 1974, the lifting of price controls in the U.S. resulted in tremendous demands placed on the steel and steel fabrication industries due to the energy crisis. This factor, together with the large contractor backlog of energy-related project work, created a climate for rapidly increasing costs. Shop capacity was not available to meet the demand and late deliveries became a normal occurrence. By looking at process plant construction cost trends over the past 60 years, it was difficult to fully anticipate the dramatic cost increase that occurred in 1974. Prior to mid-1973, process plant costs continued to rise each year in a relatively stable manner within a range of 3 to 5% annually. A drastic increase in various plant-component costs started in the latter half of 1973. Demand surged, prices rose, and delivery time lengthened for both finished equipment and the materials and energy for making it. The cost of plants rose 15% from the beginning to the end of 1973. The rise continued on through early 1974, and took an upward turn in May 1974 after all wage-price controls were lifted. The inflation continued to gain momentum until the fall of 1974. The overall increase in 1974 accounts for 40% [27].

As a result, who could predict price rises in 1974 of 100% for carbon steel pile, valves and fittings, 75% for reinforcing steel and 70% for pressure vessels? It is a hard question to answer. A best judgment of an experienced estimator derived from "in-house" information, historical data, market predictions, at least, will enable us to attain a reasonable escalation allowance.

4.3.1 INFLATION AND ESCALATION

Inflation is an increase in costs due to price level changes over a period of time. Escalation, in fact, is the suitable allowance for cost increase of a particular item due to the effect of inflation. As a graphical example, steel prices have risen 50% in the past six months; suppliers cannot meet the demand; and deliveries are uncertain. All these conditions contribute in their turn to increased construction costs, or escalation!

Therefore, it is of utmost importance to set up a project estimate base date and the center of gravity of each activity period in assessing escalation allowance to compensate for unknown price increases [10].

4.3.2 INFLATIONARY TRENDS FOR INTERNATIONAL PROJECTS

The impact of inflation of the capital cost estimate for international projects can hardly be overstated. The escalation provision has the aim of making a suitable allowance in the cost plan for cost increases mainly due to inflation. Inflation is an important part of the real world, and in recent years, the rate of inflation has accelerated particularly in developing countries. Continuing upward pressure on price levels is expected to come from the rising costs of energy and other limited resources, the need to restore profitability through higher prices in basic industries and an intensifying struggle for income distribution in an era of slow economic growth. This results in particular uncertainty in forecasting inflation in many parts of the world. However, inflation forecasts based on extrapolation of the present experience, modified to some extent by an optimistic or pessimistic bias, can give a more confident approach to international plant cost escalation. "In-house" information concerning inflationary trends must be developed to keep track of the plant cost escalation in different countries. Fig. 7 shows inflation rates for some selected countries during the 1970-1979 period. This figure shows double-digit inflation in Great Britain and Mexico, which, since 1973, has ranged between 10 to 20 percent annually. The U.S.A. inflation rate showed only single digit escalation until 1978 when it jumped to 10.3 percent and eventually reached the 1979 level of 13.3 percent. One

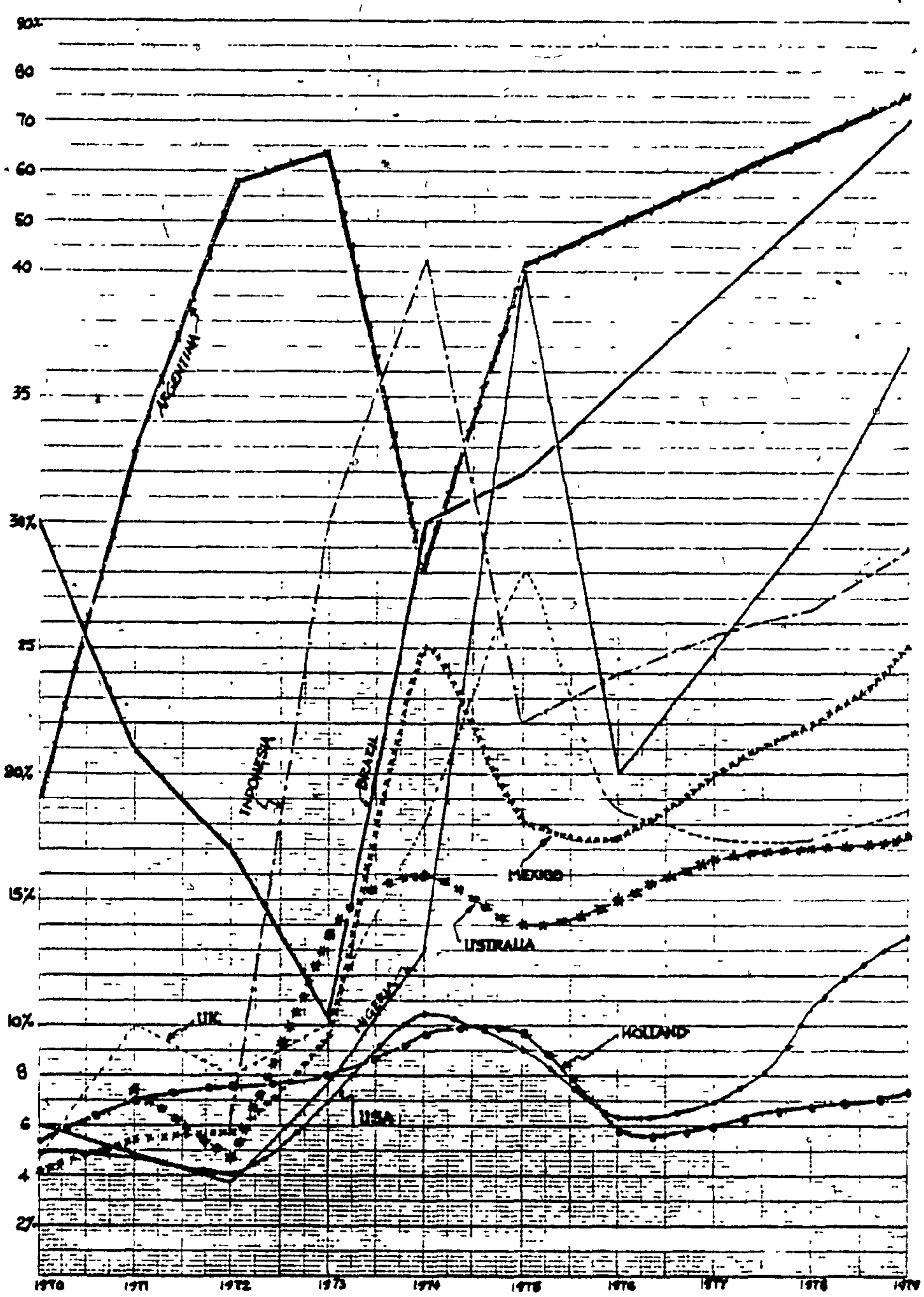

Fig. 7 Time Variation of Annual Inflation Rates for Selected Countries [29] & [30]

country with an uncontrollable inflation rate is Argentina whose inflation since 1976 has exceeded 400 percent and varied widely since then. As a result, inflation has jeopardized the traditional practice of measurements by using past experience as the starting point and basis for estimating further plant costs.

Construction cost escalation in the 1980's will be dominated by uncertainties over the rising costs of energy and interest rates.

Thus, although many inflation forecasts tend to move in the same direction, there is often a discrepancy among the various measures. As a result, there is no single correct measure for inflation. In addition to inaccuracies and measurement problems which can serve to distort a particular inflation index, the different scope of indexes will often lead to different inflation rates. Carefully selected components of published indexes are frequently the best data available for resolving specific cost and escalation questions.

4.3.3. METHODOLOGY FOR ESTIMATING ESCALATION ALLOWANCE

The following methodology is based on the procedure used by Montreal-based S.N.C. Group for estimation allowance:

i) Prepare the most accurate and detailed estimate possible based on present-day costs. It is of utmost importance that all costs have the same base date. (If a common date is not used, any overall application of an escalation rate loses accuracy. Further, subsequent revision to an estimate becomes unnecessarily complicated if the time base is not fixed).

ii) Determine the percentage cost breakdown for the different major components of the work.

a) Materials and Equipment: Delivered cost, including freight and taxes. Include tools, equipment and consumable supplies.

b) Labor and Associated Costs: Include all construction labor and labor-related charges.

c) Engineering and Project Management.

This breakdown is obtained from the basic estimate.

In our example, let us take a refinery and petrochemical plant where the percentage of component breakdown may be:

Materials and Equipment	63%
Labor	25%
Engineering and Project Management	12%

It is possible, at this stage, to also identify possible problem areas for special consideration later.

iii) To assign escalation rates for each of the cost components. These rates are obtained from company records, published cost indices from the countries concerned, Engineering New Records, Chemical Engineering, Oil and Gas journals, Engineering and Process

Economies, etc., and checked with actual suppliers, manufacturers, etc. For international projects, escalation rates are usually more difficult to obtain and considerably less reliable. Currency reevaluation may cause abrupt changes in the economies of an area, and political changes can cause a wide swing in the business climate.

Let us assume that the escalation rates to be used are as follows:

Materials and Equipment	12%
Labor	6%
Engineering and Project Management	8%

A project scedule is now prepared. From this and the cost estimate, the mid-point for each of the subject activities is determined. (Assume that the commitment curve for a cost category is symmetrical about the mid-point with respect to time, and that the escalation rate is uniform during the project. The errors introduced by these assumptions have been neglected on all but the most unusual projects). Assume project duration to be 36 months and present day project is estimated to be $150 million.

Materials and Equipment Procurement	18 months
Labor	24 months
Engineering and Project Management	16 months

From the above information, the actual escalation allowance is calculated:

Materials and Equipment:	$150 million x 0.63 x 0.12 x 18/12 =	17.01 mil
Labor :	$150 million x 0.25 x 0.06 x 24/12 =	4.50 mil
Engineering & Project Management :	$150 million x 0.12 x 0.08 x 16/12 =	1.920 mil
TOTAL ESCALATION ALLOWANCE		23.43 mil (15.62 %) say 15.6%

Escalation is the biggest single problem in estimating international Capital Plant Costs during recent years. The size of the problem arises not so much from its complexity - it is, in fact, a rather simple problem - but rather from the obscureness of the causes, the magnitude of the changes and the uncertainty of the trends. There is sufficient evidence to indicate that, despite the best effort of the world's financial and political leaders, high rates of inflation of perhaps 12-35% could reappear in many more parts of the world, particularly if the price of oil continues to rise. Moreover, the demand for full employment in the industrialized countries and for an increased share of the cake from underdeveloped countries could easily put a strain on the present monetary system that can only be relieved by high inflation. As a result, the art of estimating escalation allowance will depend greatly on a company's good retrieval system of past projects, the estimator's judgment backed by years of experience, an "up-to-date" knowledge of and research into current cost trends which goes into it and perhaps good luck.

Chapter 5

RISK ANALYSIS

The objectives of this chapter are:

(i) To describe the process of risk analysis for a capital cost estimate.

(ii) To identify risk analysis for "firm-price" proposals.

(iii) To outline the methodology of risk analysis in capital cost estimates.

International construction projects deal with the future which is full of uncertainties. A primary consideration of management in making business commitments is the risk of the proposed project since, within the confines of corporate policy, innovative strategies needed for the project cannot be made by senior levels of management unless they know the causes of sources of risk as well as their monetary values.

Capital cost estimates, which are less than 100% accurate, forecast the future; contingency is added to minimize risk; and business commitments are made on the resulting numbers. As a single number for the estimated total project is presented to management, they are left in the dark as to the chances of doing much better or much worse than the number presented. Since every one of the many parts that make up a cost estimate is subject to some uncertainty, management needs to see what the effect of the uncertainty surrounding each of the significant parts has on the total cost estimate.

Should management decide to bid or not to bid on an international project based solely on the capital cost estimate? This is the main reason why a consistent and comprehensive risk analysis is prepared to review by management. A good judgment of risk, as a result, is an important ingredient for reaching a "best" decision, since it is able to form a measure of the riskiness of a project. Thus, while a risk analysis cannot possibly devise ways to eliminate all risks, it can advise management on how to gamble if necessary. And, in today's uncertain world, management must reconcile themselves to gambling.

5.1 RISK ANALYSIS FOR "FIRM PRICE" PROPOSALS

Risk analysis for "firm price" proposals is a technique involving a methodical approach to identify, evaluate and measure uncertainties due to variables which are not commercially insurable, in order to apply available counter-measures and remedies to reduce or eliminate them. The technique is prepared for proposals involving supply of equipment, material and home office services on a firm price basis. Variables, which usually are commercially insurable, are not covered by the above-mentioned risk analysis. These variables are blockage of funds from abroad, inconvertibility of funds from abroad, war, revolution, insurrection, riots in buyer's or seller's country, cancellation of non-renewal of imposition or restrictions on export/import permits, Acts of God, interference or harassment of staff abroad, imposition of foreign taxes, owner insolvency, marine transportation risk, as well as owner contract cancellation.

5.2 METHODOLOGY OF RISK ANALYSIS IN CAPITAL COST ESTIMATE

The methodology consists of a simple sensitivity analysis, based on preparing a realistic cost estimate of the scope of work conforming to the contractual documents, under the most likely conditions, and by carrying throughout the analysis a judgment on the possible range of each variable from the most pessimistic conditions to the most optimistic conditions. The total exposure under the most pessimistic, the most likely and the most optimistic conditions are developed and compared with the available money carried out in the realistic estimate to compensate for the most likely exposures. If required, judgment is used to recommend a risk factor over and above the realistic estimate to cover such total exposure. The procedure resembles that of the PERT-type activity planning.

Although it is a fact that there is little likelihood that all variables taken into consideration will end up at the extremes of their ranges, all at the same time; to simplify the method, no attempt is made to aggregate the uncertainties at this time.

The detailed procedure of risk analysis is beyond in the scope of this report. However, forms used for presentation of capital cost estimate and its related risk analysis is included in Appendix G for reference purposes.

Chapter 6

PROJECT FINANCING

The objectives of this chapter are:

(i) To introduce the concept of project financing for international work.

(ii) To identify different sources of financing available, their related operating agencies.

(iii) To describe the conditions and procedures to follow to obtain possible financing from these sources.

The financing of an international construction project has a considerable influence on its final capital cost and in getting the project off the drawing boards and into reality. Project Financing can be accomplished by one or a combination of following formats:

- Wholely financed by the client using his local currency
- Partially financed by the client, using his local currency and with one or more financial instruments, such as credits or finance provided by the seller's country. The major sources of such financing in Canada are EDC (Export Development Corporation), CIDA (Canadian International Development Agency), Canadian-based banks.

For present-day international projects, the engineering firm has to arrange the financing for the client from EDC, CIDA, Canadian banks, etc. This represents special and complex problems in many different areas, ranging from credit policy, marketing techniques to different national borrowing conditions and export payment guarantee programs. The fact that two countries (or more) are involved automatically increases the complexity, introducing the factor of exchange risks, the possibility of having inadequate knowledge about the financial strength of foreign customers, as well as the problem of special financing costs.

Most of the developed nations have established their own export-credit institutions for various types of development and project financing. Since every government promotes exports, many countries have programs to reduce exporting risks. These programs give the exporting engineering firm the option of having government agencies providing long-term financing at reduced costs and of insuring various types of risks such as political, commercial and currency ones. Consequently, the competitive race for export orders, particularly for capital equipment, which requires long-term payment arrangements, as well as the efforts of governments in industrialized countries to capture a large share of this market for their nationals have enhanced the role of public financing sources. In Canada, the impressive growth of EDC in the past few years indicates the important role of EDC in today's project financing.

Besides public financing sources, commercial banks are the most important source of international project financing. Over the past few years, banks have vastly expanded their international financial services to cope with all aspects of project financing. With their huge capital bases and their flexibility and ingenuity in public and private financing, commercial banks have combined their lending activities with their exchange market capabilities to offer credits that can be drawn or repaid in a variety of currencies. They have been increasingly tailoring credits to fit their customers' demands and have been granting larger credit packages as well as more diversified financing facilities. They have moved into international cash and exposure management, global project analysis and financial counselling. Banks have also restructured pricing systems and have reduced profit margins in response to increased competition. Thus, they have taken a dominant role in becoming involved in long-term project lending.

6.1 PUBLIC FINANCING

Generally, an excellent export financing scheme can be obtained from the Export Development Corporation (EDC), a government agency. EDC was established in October 1969 under the Export Development Act proclaimed by Parliament, as the successor to the Export Credits Insurance Corporation (ECIC) which commenced operations in 1944. It provides financial services to facilitate and expand Canadian export trade and create employment at home. It provides term loans to foreign purchasers of Canadian goods and services, guarantees private loans to such purchases when credit cannot be obtained on reasonable terms from commercial sources, and insures foreign investments by Canadian residents. However, the facilities provided by EDC do not subsidize exporters. Canadian firms compete in foreign markets on the normal commercial basis of price, quality, delivery and service. EDC facilities are widely used by foreign-owned affiliates in Canada. EDC has an operating capacity of 26 billion Canadian dollars, and its assets at the end of fiscal 1978 exceeded $2.3 billion [32]. Its long-term financing ceiling is C$10 billion, but another C$2.5 billion is available, subject to government approval. In 1978, EDC's business volume rose to C$6 billion more than double the 1977 amount. The Corporation arranges and guarantees loans to buyers of capital equipment and technical services. It often works closely with the banking community to provide internationally competitive financing. In deals jointly financed by the EDC and commercial banks, the EDC usually provides the major part (about 70%) of the funds. Conversely, the banks provide down payment, construction-period and local cost financing not normally covered by EDC lending. Although loans are made to the foreign buyer, applications are generally submitted by the Canadian exporter, who receives the disbursements directly. In 1978, a record was set in the extension of a C$1.2 billion line of credit to Algeria. This line can fund any project undertaken by Canadian suppliers who meet the EDC's eligibility criteria. In May 1979, an even bigger line of credit, for C$2 billion, was granted to China. Examples of loans or guarantees made during 1978 include U.S. $667 million guarantees to Bechtel Canada, to design and build a gasgathering system, treatment plant and rejection system for Algeria's Entreprise National Sonatrach (the EDC's main financial partner in this deal was the Toronto-Dominion Bank) [32].

To qualify for EDC assistance, an export transaction must provide significant profit to Canada, such as enhancing Canada's technical reputation abroad, increasing industrial stability at home, gaining better access to world markets, gaining actual high dollar value of Canadian equipment, materials and services involved in a project. Maximization of Canadian content is a requirement for all transactions supported by EDC.

To apply for EDC financial assistance, Canadian engineering firms requiring long-term financing to obtain a major order of capital equipment and engineering services for an international project abroad must submit an application with the following information:

a) Information concerning exporter

- Describe exporter's corporate history and operations including subsidiaries, affiliates, major shareholders and parent company (if any).
- In case the exporter is a subsidiary, does it have complete freedom to initiate export business? If not, what limitations are placed on its operations by the parent company?
- Attach audited financial and ancillary statements of exporter for the past five years. For each of the past five years, list exporter's total domestic and export sales, domestic and export sales of equipment

of the type requiring present financing.

- On the basis of existing firm capacity, state in dollar value: maximum output, optimum output, present output, level of output if proposed project undertaken (i.e., Manhour x Cost/Hour).
- Show the number of employees of the company as of the latest available date and as of at least one year ago. Give the company's average annual employment over the past five years.
- Describe the employment situation in the area where production facilities are located, giving the latest number and percentage of unemployed, and for the last three years.

b) Information concerning borrower

- Describe borrower's corporate history and operations, including subsidiaries, affiliates, major shareholders and parent company (if any).
- Attached audited financial and ancillary statements of borrower for the past five years, including details of payment terms and interest rates of borrower's present outstanding debts.
- Attach borrower's forecast: balance sheet; income statement; statement of source and application of funds including working capital; capital expenditure schedule. Forecast should cover the period of construction and extend for a further period of at least five years.
- Provide details of additional equity and debt financing contemplated

by the borrower during the above forecast period.

- If the borrower is undertaking a new venture, or entering a new field of activity, supply in complete detail provisions which will be made for supply of experienced management during the first five years of borrower's proposed operations.

c) Information concerning project

Describe the project fully, giving detailed information on the following: Nature of the project, location, economic and technical soundness, viability, national and regional importance in the importing country, further engineering before construction commences, project costs to be paid in Canadian or U.S. dollars?

It is essential that satisfactory feasibility studies, tender specifications and other reports concerning the project be presented with the application to establish the technical and economic soundness of the transaction requiring financing.

Four important factors to be mentioned are:

i) TIME: State the anticipated periods and dates related to the project for completion, start-up, construction period, delivery period of the equipment and material at site, placing of orders, signing of contract agreement.

ii) COST: Provide details of project costs such as total cost of project, local costs and how to finance foreign exchange costs (Canadian), foreign exchange costs (Non-Canadian) and how to finance foreign agents' commission, fees and royalties (if any) and how to finance the company's anticipated net profit after income taxes.

iii) CANADIAN CONTENT: State the overall percentage of Canadian content of the project calculated according to EDC criteria. Indicate the equipment, material and services to be supplied by the company and by his main suppliers, giving names of suppliers, and dollar values. For equipment or materials purchased in Canada, those which have non-Canadian content must be considered when computing the overall Canadian content of the project.

iv) TERMS OF FINANCING REQUESTED: State clearly financing terms required for project, supply detailed and verified information justifying terms requested, i.e., What is foreign competition offering? State name of agency or department of government which will provide guarantee of principal and interest, state name of central bank, etc., which will provide guarantee of foreign exchange availability.

d) Information concerning benefits of the project to the economy of the importing country

- Describe the economic benefits the importing country will derive as a result of this project coming into production with respect to employment, use of domestic raw materials, additional revenue to the government concerned and foreign exchange saving, etc.

- If the importing country has a National Development Plan, attach a copy of the Plan and give the priority of this project under the Plan.

e) <u>Information concerning benefits of the transaction to the Canadian economy</u>

- Describe any special industrial advantages to be derived from this transaction in terms of utilization of labor force and plant capacity, of assistance or encouragement in developing new designs or lines of production, and of increasing Canadian manufacture of equipment or component parts.
- Specify the export trade promotion benefits that may be expected to result from this transaction with regard to direct market development prospects in the country of purchasing area as well as countinuing market for replacement parts of Canadian origin.
- Describe the direct and indirect labor effects in Canada for the applicant company, each of the main associated firms and sub-contractors and for the total project transaction as a whole.

Another source of public financing is CIDA (Canadian International Development Agency) whose sponsored projects offer a means by which Canadian-based engineering firms can obtain international exposure in a non-internationally competitive environment [11]. It is an agency designed to support the development of foreign countries by funding foreign-based projects in developing countries. Thus, foreign-based projects delivered and operated on a joint venture with local engineering firms are eligible for CIDA support; those delivered on a turnkey basis by Canadian engineering firms are ineligible. The Canadian-based engineering firm must have a majority Canadian ownership to be eligible for CIDA-supported projects. To award a contract to a Canadian firm, CIDA considers the following criteria:

- "Track record" of the company for a minimum period of three years.
- The rules of the host country where project will be executed.
- The competitiveness of the bid.

Furthermore, during the decision-making process, CIDA consults with the foreign post, Department of Industry, Trade and Commerce, EDC and the Canadian chartered banks.

The largest source of financing for international projects is the World Bank, whose lending and investment activities are directed to promoting economic development in the less developed countries of the world - mostly in the Third World. The bank provides financial and technical assistance for projects in a wide range of economic sectors. It consists of three main financial institutions: the International Bank for Reconstruction and Development, which makes loans at nearly conventional terms for projects of high economic priority; the International Development Association, which provides credits on concessionary terms to countries that might otherwise not be able to obtain financing; and the International Finance Corporation, which finances various projects in the private sector through loans and equity participation. The World Bank requires international bidding for the goods and services they finance. Although most loans and credits are denominated in dollars, actual disbursements may be in any of a number of currencies. Engineering firms engaged in international projects may benefit from the World Bank's activities in a variety of ways such as supplying to projects in developing countries for which the bank disburses billions of dollars, borrowing from the 107 development financial institutions that the bank has assisted financially and technically, being beneficiaries of an improved business climate resulting from the World Bank's general and specific activities in developing countries, e.g., upgrading infrastructure and technical capabilities, improving economic management and reliable inventories of economic resources as well as being recipient of the World Bank financing for joint projects with local business in developing its member countries. The World Bank is currently helping to prepare 30 oil and gas projects; approximately half are in countries where annual per capita income is below $500 U.S. Of these projects, 22 are expected to be formally considered for financing between 1979 and 1981 [32]. Five loans for coal production projects are also expected to be considered. There is no standard criteria for the awarding of World Bank financing of a project. However, certain information is required to decide if a project proposal merits a contract award consideration, such as:

- A description of the proposed project and of the company.
- The company's legal status and its financial history.

- The company's present and proposed operations.
- The amount of financing needed and the purpose for which it is required.
- Financial forecasts of operating results.
- Information on the cost and availability of raw materials and other inputs, together with a review of technical assistance or other agreements in developing the country concerned.

6.2 COMMERCIAL BANK FINANCING

Commercial banks are important sources of Project Financing. Canadian banks have only established specialized project financing departments since 1974 and this generally was a reaction to the emergence of large energy-related projects resulting in the need to marshall a substantial sum of money [33]. Project Financing, in the commercial bank's viewpoint, is the financing of a major economic undertaking primarily on the strength of the economic viability of the project, underpinned by credit support arrangements that seek to protect the lender against specific project risks while limiting the bank's recourse to the project sponsors - e.g., it is a loan that is to be repaid primarily from the earnings of the project in a situation where both the lender and the sponsor are trying to minimize their respective risks. The commercial banks, thus, want to avoid a company who wants to assume as little of the project's risk as possible by minimizing their financing contribution and by-passing as many of the risks as possible to the lenders, their suppliers, their prospective customers and, in some cases, to the government. As a result, the negotiation of a project financing between an engineering firm and a commercial bank is the negotiation of which risks the parties to the transaction are going to assume. The major service of Canadian banks is to provide debt financing for a use of funds with domestic risk, such as Canadian-sourced production, as well as bid and performance bonds. Canadian banks generally do not provide debt financing for a use of funds with "non-Canadian" risk such as civil work in the host country. The arrangement of financing from a Canadian bank follows these stages:

a) If project financing is requested, the commercial bank will determine whether or not the project can be delivered in time, according to technical specifications and at estimated cost.

b) The bank will next determine possible financing for the firm by doing an independent risk-profile analysis of the firm which includes:

   1. The company's track record - e.g., experience on previous projects.

   2. The firm's managerial capability - e.g., Does the company have the technical, marketing and managerial expertise required to bring off the project?

   3. The completion risk of the project - e.g., Will the project be completed within the cost, time and quality parameters as originally envisaged taking into consideration factors

such as inflation, inadequate financing, material shortages, labor problems, serious technical problems in start-up?

4. The company's financial strength - e.g., examine the company's income statement, balance sheet, statement of accounts receivable, schedule of contract values, etc., covering the last four of five years.

In other words, in the risk profile analysis, the following questions concerning the engineering firm must be answered satisfactorily before the bank considers possible finance for the project:

- Does the company utilize executive staff with previous international experience?
- Does he uses a local partner who:
  - (i) Understands and is involved in the construction market
  - (ii) Is well-known and reputable
  - (iii) Can help solve payment problems and visa problems through working experience with the government?
- Can the company perform without local subconstractors and does it obtain prime guarantees from them if it does use them?
- Does the company base its bid prices on a detailed survey of the market and utilize contingency and overhead allowances which reflect the pecularities of the specific market?
- Does the company bid high enough so that the return on a project it wins will be large enough to match its risk and effort?

- Does the company take projects involving cost components with which it is familiar and over which it can maintain certain control?
- Does the company start mobilization as quickly as possible upon signing the contract?
- Has the company made allowances for potential inflation?
- Is the company's financial base, cash flow and financial management strong enough to support its operation? What happens if problems develop?
- Does the company manage its foreign exchange correctly?
- Is the company's prior international track record good enough to justify the scale of its planned international project?
- Does the company maintain an adequate dialogue with its bankers about operations, future plans and current developments?

Thus, from an international engineering firm's viewpoint, maximum credit will be available from the banker if the company can provide commercial banks with detailed information on the firm's management, operations and past experience on contracts, as well as on the general trends and conditions in the markets where the company wants to operate since the only way commercial banks can measure the company's strength - an inexact science - is to understand the entire context of the engineering firm's operation, and then determine the sufficiency of the company's financial health and its management ability.

c) Before the financial funds are advanced, the bank generally requires the company to provide adequate collateral - e.g., the bank attempts to protect itself by having the account receivable assigned to the bank, as well as by securing the personal guarantees of the firm's owners and key individuals.

Besides, political risks associated with a foreign project such as war, unilateral expropriation as well as those at home such as changes in tax and royalty treatment, changes in environmental considerations, are also studied by commercial banks. The four biggest commercial banks in Canada provided project financing for international projects are the Royal Bank of Canada, the Canadian Imperial Bank of Commerce, the Toronto-Dominion Bank and the Bank of Montreal.

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

The generation of new business abroad is a distinct and conscious development effort where time, cost and quality involved are the main factors to the effective pursuit of international projects. Good international capital cost estimation results in the eventual effective planning, estimating and cost control functions in Project Management where the inter-related parameters of Quality, Cost and Time are of utmost significance from inception to completion of an engineering venture. International corporate decisions are based on effective capital cost estimate whose information provides a basis for management decision-making.

The international capital cost estimate procedure presented in this report is a fast method to prepare a cost estimate for heavy industrial plants for international bidding purposes where information related to the project is minimal at this stage. This estimating approach - one of many approaches - is directed to meet the above-mentioned factors where answers must be reached within the shortest possible time and in the most efficient manner despite the ever-increasing complexity of processes, the increasing change in technology and the remoteness of plant site. It must be emphasized that the estimating approach presented in this report is in no way intended to replace a more detailed definitive estimate where more information is available, although it may help to double check the detailed definitive estimate and pin-point variations that may need further investigation of design or layout decisions.

International Capital Cost Estimate for heavy industrial plants is, thus, one of the essential and useful tools of today's Project Management in the development of construction engineering business abroad. It involves preliminary judgment and great risk at the early stage of a project when project information might be changed easily. Good reasonable accuracy of the estimate can be obtained when the project concept is clear and the limits of the estimate are known. The study of capital cost estimation described herein should be improved to eliminate certain drawbacks of the approach. Attention should be directed at:

(i) improving the measurement of risk exposure especially during period of great economic uncertainty

(ii) refining the calculation of escalation changes

(iii) incorporating the impact of financing charges in the design-decision making process

The following topics are suggested for consideration for those pursuing further research work on capital cost estimating for heavy industrial plants

1. Standardized computer capital cost estimating for heavy

industrial plants;

2. Effective method to predict the escalation trend for process plant construction;
3. Standardized mathematical approach in estimating contingency allowance and escalation allowance;
4. Detailed and systematic risk analysis for capital cost estimation;
5. Scientific methodology in assessing capital cost accuracy; and
6. Preliminary capital cost estimation for heavy industrial plant - domestic versus international project.

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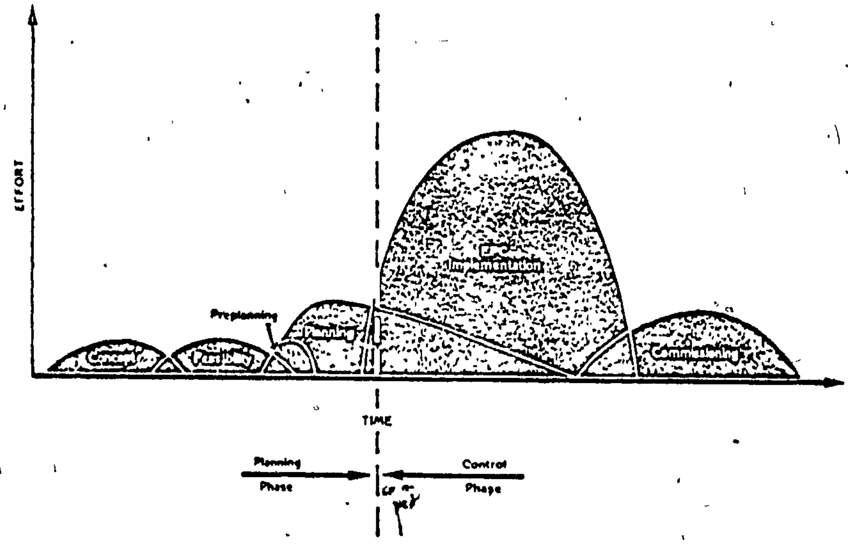
APPENDIX A

PROJECT PHASES AND PROJECT SERVICES



PROJECT PHASES AND PROJECT SERVICES

1 CLIENT	PROJECT POLICIES, DECISIONS , REVIEWS, APPROVALS				
		APPROVALS	APPROVALS		ACCEPTANCES
2 COMPANY MGT	IN-HOUSE POLICIES, DECISIONS, REVIEWS, APPROVALS, SUPPORT (Finance, Legal, Personal, Public Relations				
3 PROJ. MGR			Lead Pre-planning Project planning Plan Insurance,Public Rel. Legal, Personnel	Continuous Package Coordination, Control Reporting Client, Company Management	
4 P M S *	PROJECT ADMINISTRATION				
Planning & Scheduling	Preliminary Schedule	Preliminary Master Schedule	-Pre-planning -Master Schedule -Project Breakdown -Bid packages -Coding -Network schedules	- Larger detail network - Construction worksheets - Reporting	
Estimating	- Order of Magnititude Estimate	Preliminary Estimate Value Engineering	-Pre-planning -Coding -Bid package - Definitive Package (target) -Value Engineering -Change control	- Value Engineering - Control Estimate - Tender check Estimate - Claim & change order estimate - Forecast to complete	- Project historical Data
Cost Control	preliminary planning	financial	-Pre-planning - coding - Financial planning	- Cost Control, Accounting and Report - Forecast to complete - change control	- Plant ledger
5 Engineering		-Process -Plot plan -Layout -Site locating	-Pre-planning -Process Design Package -Design criteria -Plot Plan -P & I diagrams -Layouts -Specs for major Equipment -Soil investigation -Single line diagram -20% of detailed Eng. design -Engineering part of definitive estimate package	DETAILED ENGINEERING AND DESIGN - Mechanical for process - Automation/Instruments - Electrical - Civil -Structural - Mechanical for bidders - Work/Quality Control - Models -Computer applications - Drawings and Specifications - Recommended bidders' list - Request to issue tender	- Information to to bidders - Technical Bid Comparisons
6 PROCUREMENT	market review Prel logistic review Prelim procurement plan	Inquiries for major groups of equipment long lead time items inquiries Procurement budget Procurement Plan Preliminary procurement In-depth logistics study	- Pre-planning - Final Methods & approach for procurement - Master Schedules - Bid packages - Documentation for contract - Overseas Activities	- Construction contracs - Purchasing - Expediting - Material Control - Logistics - Inspection liaison	
7 CONSTRUCTION MANAGEMENT			- Pre-planning - Plan temporary facility - Planning	- Bidder's site visit	
8 COMMISSIONING			- Pre-planning - Planning	- Planning - Assist Project team	- Pre-commissioning - Commissioning - Operation - Maintenance
AUTHORITIES REGULATORY BODIES, PUBLIC UTILITIES					

* (project management services)

APPENDIX B

FOREIGN COST AND SITE SURVEY CHECK LIST

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SECTION	Sub Section	SUBJECT
9.0		DUTY
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	10.1	Labour Laws ....
	10.2	Building Code ....
	10.3	Pollution Laws ....
	10.4	Various Laws ....
11.0		CONTRACT FORMS (FREQUENCY OF USE)
	11.1	Lump Sum ....
	11.2	Cost Plus ....
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	11.4	Joint Venture ....
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	11.6	Contractors (List & Rating) ....
12.0		INDIRECT COSTS (FIELD)
	12.1	Labour Assessments ....
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	12.6	Unallocated Material Expenses ....
	12.7	Construction Facilities
		Camps ....
		Shops ....
		Services ....
		Product Plants ....
		Material Handling Facilities (At Site) ....
13.0		CONCRETE AGGREGATE
14.0		ENGINEERING

INTRODUCTION

SUBJECT	-	Foreign Cost and Site Survey Manual
PURPOSE	-	To serve as a GUIDE CHECK LIST in collecting information about a project in a foreign country - mainly information which is required to prepare a reasonably accurate estimate of the capital costs.
DETAIL	-	While the check list is detailed and elaborate, it is recognized that, for a specific project, information on some items would not be relevant or required. In other situations it may not be detailed enough.
USE	-	Since it is intended to be used as a guide, the person responsible for providing the answers should use his discretion in determining which items are to be pursued and which are redundant.

GENERAL DATA

PROJECT (for which this survey is undertaken)

....

....

....

CLIENT ....

....

....

COUNTRY ....

....

....

LOCATION AND SITE (Sketch)

PERSON RESPONSIBLE FOR PROVIDING INFORMATION
(or, ESSENTIALLY COMPLETED BY)

....

....

....

1.0 CURRENCY

1.1 Rate of Exchange .... Date ....

2.0 CLIMATE

2.1 General

a) General description of climate over one year noting extremes and seasonal variations ....

2.2 Temperatures

Low .... Duration - Cold ....wks
Mean .... Duration - Med ....wks
High .... Duration - Hot ....wks

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2.3 Humidities

Low .... Duration ....
Mean .... Duration ....
High .... Duration ....

2.4 Precipitation

Annual Precipitation

Summer .... From ....
State months ....

Winter .... From ....
State months ....

Amount in 24 hours ....
Twenty minute intensity ....

2.5 Wind

Max'm Strength ....
Prevailing ....

2.6 Flood Risk ....

2.7 Earthquake Risk ....

2.8 Estimated loss of working time due to weather ....

3.0 GEOGRAPHY (Special Conditions of Terrain or Subsurface)

3.1 Excavation (e.g., type of soil, rock, shoring, pumping, piles, ground water, or no special conditions) ....

3.2 Foundations (e.g., rock, piling, shoring, frost cover, or no special conditions) ....

3.3 Surface Grading (e.g., flat, rocky, cut/fill depth, dewatering) ....

4.0 LABOUR

4.1 Basic Wage Rates (Without any Fringes - See Items Following)

Bricklayer ....
Carpenter ....
Cement Finisher ....
Electrician ....
Equipment Operators
  Truck driver 1-1/2T ....
  Tractor 100 HP ....
Labourer ....
Millwright ....
Painter ....
Pipefitter ....
Plasterer ....
Plumber ....
Roofer ....
Sheet Metal Worker ....
Structural Iron Worker ....
Tile Setter ....

Are these rates tied to an official cost of living index? .....

What is the trend of this index?..............................

4.2 Escalation Rates

Calendar Year 19 ....
....
....
....
....

4.0 LABOUR (CONT'D)

4.3 Working Hours

Normal per week ....

Prevailing per week ....

4.4 Extras (To Basic Wage Rates)

Overtime Premium ....

Shift Work ....

Height ....

Tool or "dirty" money ....

Others: ....

....

....

4.5 Fringe Benefits

Unemployment Insurance ....

Workmen's Compensation ....

Health & Welfare ....

Vacation ....

Holidays ....

Pension ....

Education Funds ....

Others: ....

....

....

....

....

4.0 LABOUR (CONT'D)

4.6 Social Benefits

Room & Board ....

Transportation

Point of Hire to Site ....

On jobsite ....

Periodic ....

Fares ....

Travelling Time ....

Overtime Premium ....

Guaranteed Time Premium ....

Bonuses ....

Recruitment Charges ....

Retrenchment payments ....

Others: ....

....

....

4.7 Productivity of Labour

Express opinion

Ratio $\frac{\text{*MH req'd in loc'n under study}}{\text{MH req'd in Canada}}$

to do the same job

* MH - Manhours ....

Quality ....

4.0 LABOUR (CONT'D)

4.8 Availability of Labour

General market conditions for labour supply ....

Any other project competing for limited labour resources ....

Numbers of workers available

a) immediately adjacent to site ....

b) within daily transport range? ....

Level of employment

Carpenters ....

Electricians ....

Labourers ....

Millwrights ....

Pipefitters ....

Struct'l Steel Erectors ....

Staff (Local)

Availability ....

Quality ....

Suitability for clerical, accounting machine operation ....

Seasonable Variation ....

4.9 Incentives

Nature and extent of local incentive system, if any ....

4.10 Unions

4.0 LABOUR (CONT'D)

4.10 Unions (Cont'd)

Unions in operation? ....

Extent of influence over labour ....

Basis

Industry ....

Trade ....

Local ....

Strikes

Frequency ....

Duration ....

Classifications

Local peculiarities ....

4.11 Imported Skills

Which skills, if any, have to be imported? ....

At what premium? ....

From what country? ....

5.0 MATERIALS AND EQUIPMENT

5.1 Most Commonly Used Materials Available Locally ....

....

....

5.2 Domestic vs Imports

What ratios of materials and equipment
are produced domestically? ....

5.0 MATERIALS AND EQUIPMENT (CONT'D)

5.2 Domestic vs Imports (Cont'd)

What are approximate average duties on imports? ....

ITEM	DOMESTIC	IMPORTED			REMARKS
	%	%	DUTY	COUNTRY	
Materials	.....	.....	.....	....	....
Wood	.....	.....	.....	....	....
Cement	.....	.....	.....	....	....
Steel - Structural	.....	.....	.....	....	....
Reinforcing	.....	.....	.....	....	....
Piping Supplies	.....	.....	.....	....	....
Electrical Supplies	.....	.....	.....	....	....
Installed Equipment					
Tanks	.....	.....	.....	....	....
Installed Equipment					
Pumps	.....	.....	.....	....	....
Air Compressors	.....	.....	.....	....	....
Electric Motors	.....	.....	.....	....	....
Boilers	.....	.....	.....	....	....
Crushers	.....	.....	.....	....	....
Instruments	.....	.....	.....	....	....
Fans	.....	.....	.....	....	....
Transformers	.....	.....	.....	....	....

5.0 MATERIALS AND EQUIPMENT (CONT'D)

5.3 Costs of Materials & Equipment (Be specific about description, quantity, and F.O.B. point)

Structural Shapes ....

Reinforcing Bars ....

Cement Portland ....

Lumber, 2" x 4", 2nd Class ....

Gravel ....

Sand (Washed) ....

Cables, conduit ....

5.4 Escalation on Materials ....

Equipment ....

5.5 Purchasing Conditions

Market conditions generally ....

Any other project competing for limited resources ....

Import restrictions ....

Local peculiarities in buying ....

Local licensing ....

6.0 CONSTRUCTION EQUIPMENT

6.1	AVAILABLE LOCALLY?	FREQUENCY OF USE	RATES	BASIS OF RATES
Trucks	....	....	....	....
Tractors	....	....	....	....

	AVAILABLE LOCALLY?	FREQUENCY OF USE	RATES	BASIS OF RATES
Earthmovers				
Cranes				
Concrete Mixers				
Pumps				
Air Compressors				

6.2 Local Agents

Service Facilities ....

Capacity ....

Stocks of Spares ....

6.3 Domestic vs Imports .... See section 5.2

6.4 Mechanization (State Equipment Used)

General ....

Site ....

Foundation ....

Bldg. Erection ....

Concreting ....

Heavy Equipment, Inst'n ....

Highway Equipment ....

7.0 TAXES

7.1 National ....

7.0 TAXES (CONT'D)

7.2 Local ....

7.3 Other ....

....

....

Are any, or portions, recoverable? ....

8.0 TRANSPORT

8.1 Railhead

Nearest railhead - distance ....

Railway gauge ....

Siding capacity available ....

Cranage capacity available ....

Is space available for a new siding, if required ....

Max'm weight & dimensions of load which can be carried ....

8.2 Deepwater Port

Nearest port - distance ....

Cranage capacity available ....

Is lighterage necessary ....

Any special or seasonal limitation on capacity ....

8.3 Airport

Nearest Airport - distance ....

8.0 TRANSPORT (CONT'D)

8.3 Airport (Cont'd)

Capacity ....

Limitations ....

Description ....

8.4 Roads

Distance of site from nearest town (est'd size) ....

Railhead ....

Airport ....

Deepwater Port ....

Hazards FROM →	TOWN	RAILHEAD	AIRPORT	DEEPWATER PORT
Culverts	.....	....	....	....
Bridges	.....	....	....	....
Landslides	.....	....	....	....
Snow drafts ...	.....	....	....	....
Others	.....	....	....	....

Bridges to be strengthened

Limitations

Size ....

Load ....

Security in transit ....

Speed of delivery ....

Intensity of exis. traffic ....

8.0 TRANSPORT (CONT'D)

8.4 Roads (Cont'd)

Suitability for staff travel ....

8.5 Freight Rates ....

....

....

....

....

9.0 DUTY

9.1 Import Restrictions

Licensing ....

Quota ....

9.2 Import Duties ....

9.3 Port & Customs Dues

Handling Charges ....

Demurrage ....

Cranage ....

Clearance & forwarding charges ....

10.0 LAWS

10.1 Labour Laws

Operation of existing legislation particularly with respect to industrial disputes ....

10.0 LAWS (CONT'D)

10.1 Labour Laws (Cont'd)

Industrial Laws (Factories Act) ....

10.2 Building Code

Snow Load ....

Wind Load ....

Earthquake ....

Frost Cover ....

10.3 Pollution Laws

Air ....

Water ....

10.4 Various Laws

Transport & Storage

Inflammables ....
Explosives ....

Fire Protection ....

Electrical Works ....

Vehicle Taxation ....

Insurance ....

11.0 CONTRACT FORMS (FREQUENCY OF USE)

11.1 Lump Sum ....

11.2 Cost Plus ....

11.0 CONTRACT FORMS (FREQUENCY OF USE) (CONT'D)

11.3 Unit Price ....

11.4 Joint Venture ....

11.5 Contractor's Fees (Head Office Overhead & Profit) ....

11.6 Contractors (List & Rating)

For: Temporary Structure, Permanent Structures, Heavy Construction, Mechanical, Electrical, Machine Shop, Haulage, Plant Hire, Equip. Hire — Prepare list on reverse side indicating

a) Name

b) Address (or location)

c) Quality

d) Capacity

e) Suitability

12.0 INDIRECT COSTS (FIELD)

12.1 Labour Assessments ....Section 4.0

12.2 Labour Expenses ....Section 4.0

12.3 Indirect Labour & Supervision

Estimate the ratio of the following CONTRACTOR'S FIELD personnel

$\frac{\text{Non-Productive (a)}}{\text{Productive (b)}}$ ....

(a) Supervision, Office, Accountants, Warehousemen, Safety, Security, etc.

(b) Personnel engaged in work which advances the physical completion of the project

12.0 INDIRECT COSTS (FIELD) (CONT'D)

12.4 General Office Expenses

*Indicate what Contractor's values would be for the following, expressed according to whatever formula is generally used (e.g., % direct labour, % of total direct cost of his work)

Communications ....

Licenses, Permits ....

Reproduction ....

Stationery & Supplies ....

Bank Charges ....

Office Equip. & Furn. ....

Municipal Taxes ....

Other Taxes ....

Insurance ....

12.5 General Construction Expenses

*See Note in 12.4

Small Tools ....

Consumables ....

Climatic Conditions ....

Clean-up ....

Temporary Buildings ....

Services ....

12.6 Unallocated Material Expenses

*See Note in 12.4

12.0 INDIRECT COSTS (FIELD)(CONT'D)

12.6 Unallocated Material Expenses (Cont'd)

Transportation ....

Loss on Damaged Goods ....

Taxes ....

Duty ....

Uncollectable Claims ....

Cancellation Charges ....

Devaluation of Stores ....

Inventory Adjustments ....

12.7 Construction Facilities

Camps

No. of men available locally ....See 4.8

Any subsistence or separation allowances payable? ....See 4.6

What charges can be made to the men? ....

Accomodation for families? ....

Any special catering arrangements required for religious or "local customs" reasons? ....

Any local customs which must be observed? ....

Accommodation available locally

For H.O Staff ....

For local staff ....

For general labour ....

12.0 INDIRECT COSTS (FIELD) (CONT'D)

12.7 Construction Facilities (Cont'd)

Shops

Are the shops in the area adequate to handle needs of project? ....

Rates, charges ....

Quality ....

Capacity ....

Will new buildings have to be constructed on site ....

or

Are buildings available for transport to site on purchase or rental basis? ....

Services (Available at Site)

Water Supply

Quantity ....

Quality ....

Seasonal Variation ....

Charges ....

Electricity

Frequency ....

Supply voltage ....

Supply capacity ....

Nearest pick-up point ....

Main transformer supplies ....

Charges - installation ....
consumption ....

12.0 INDIRECT COSTS (FIELD) (CONT'D)

12.7 Construction Facilities (Cont'd)

Communications

Nearest telephone available ....

Distance away ....

Nearest post office ....

Distance away ....

Nearest cabling facility ....

Distance away ....

Product Plants

Will any be necessary? ....

Types & Capacities (estimate) ....

Material Handling Facilities (At Site)

What facilities are available? ....

On what basis? ....

What others have to be provided? ....

13.0 CONCRETE AGGREGATE

	COARSE	FINE
Type	....	....
Source	....	....
Distance away	....	....
Transport (type)	....	....
Royalties payable?	....	....
Is washing required?	....	....
Availability of water	....	....
power	....	....

13.0 CONCRETE AGGREGATE (CONT'D)

	COARSE	FINE
Disposal of dirt		....
Quarry overburden		....
Type of crusher required, any indication		....

Suppliers (Ready-Mix) ....

Prices ....

Quality ....

Consistency of supply ....

Max'm rate of supply ....

Adequacy or otherwise of local transport ....

14.0 ENGINEERING

Types of contract most commonly used ....

Fees ....

Charges ....

Availability ....

Quality ....

Division of Responsibility ....

15.0 SITE - SPECIFIC

Topography ....

Vegetation ....

Natural Drainage ....

Existing Habitation ....

15.0 SITE - SPECIFIC (CONT'D)

Existing Services ....

Orientation ....

Site Clearing required ....

General Soil Conditions ....

16.0 CONCLUDING REMARKS (Mention any pertinent data or opinions not appearing elsewhere in report)

APPENDIX C

INTERNATIONAL QUARTERLY COST ROUNDUP FOR LABOR AND MATERIAL

World material prices

World wage rates*

(From Engineering News Records, March 1980)

APPENDIX D

PRICE ADJUSTMENT PRACTICES

Price Adjustment Practices

P. E. ULLMAN, BADGER LTD., THE HAGUE

INTRODUCTION

The following notes cover price adjustment practices in five EEC countries and three others, U.S.A., Japan and South Africa. The usual reference is to contract prices and the price adjustment formulae quoted are for price adjustment in the light of changes in labour and materials price indices after the date of the original quotation. The formulae are not intended for use in forecasting.

BELGIUM

Quoted Prices—Usually subject to escalation, except for short deliveries (say up to 6-8 months).

Type of escalation formula—
when used, is in following form:

$P_1 = P_o (0{\cdot}10 + a\, M_1/M_o + b\, L_1/L_o)$

where

- P_1 = Final Total Price.
- P_o = Quoted Price.
- M_1 = Material Price(s) last published in the "Prix de Référence Travaux Publics — Confédération Nationale de la Construction" (rates established in agreement with the Belgian government) at the end of the agreed period for material supply.
- M_o = Material Price(s) last published at date of quotation.
- L_1 = Average of "Fabrimetal" salary rates and social charge percentages during the months of fabrication. (Note that rates vary from province to province.)
- L_o = Salary rate and social charge percentage last published at date of quotation.

a and b are coefficients depending on the division of the price into material and labour components.

Buying out of escalation—usually possible to negotiate fixed prices for the life of the order without paying a premium.

FRANCE

Quoted Prices—Usually subject to escalation.

Type of escalation formula—

$P_1 = P_o (0{\cdot}10 + a\, M_1/M_o + b\, S_1/S_o)$

where

- P_1 = Final Total Price.
- P_o = Quoted Price.
- M_1 = Usually the Material Index last published in the governmental monthly "Bulletin official des Services des Prix" (B.O.S.P.) at end of first two-thirds of order period (note that sometimes more than one material index is used, e.g., for some tubular equipment the steel plate index is used together with the steel tube index).
- M_o = Material Index last published at date of quotation.
- S_1 = Usually the arithmetic mean of the values during the last one-third of order period of the "Indice S de l'Industrie Mécanique et Electrique" published by the Institut National de la Statistique et des Etudes Economiques (I.N.S.E.E.).
- S_o = Salary Index last published at date of quotation.

a and b are coefficients depending on the division of the price into material and labour components.

Buying out of escalation
Possibility exists, but not common, and no reliable percentage available.

W. GERMANY

Quoted Prices—Usually subject to escalation.

Escalation formula — Not normally used.

Buying out of escalation—Usually possible to negotiate fixed prices for the life of the order without paying a premium, except for electric cable the price of which is tied to the price of copper on the London Metal Market.

HOLLAND

Quoted Prices—Mostly subject to escalation, depending on type of equipment or material, and the delivery time, some vendors advise they are prepared to fix material costs and escalate labour portion only, and some the reverse.

Type of escalation formula—When proposed, has following typical form:

$P_1 = P_o [(0 \text{ to } 0{\cdot}10) + a\, M_1/M_o + b\, S_1/S_o]$

where

- P_1 = Final Total Price.
- P_o = Quoted Price.
- M_1 = Average of wholesale price indices for the materials involved, as published by the Centraal Bureau voor de Statistiek (C.B.S.) applicable at an agreed time from the start or before the end of the contractual delivery period.
- M_o = Similar average of indices for the month (or the month prior to that) of the quotation.
- S_1 = Index for adult wage rates in the metal industries as published by the C.B.S. and applicable at the contractual delivery date

  OR

  the average of the same index values for the agreed latter part of the order period.
- S_o = Similar index for the month (or the month prior to that) of the quotation.

a and b are coefficients depending on the division of the price into material and labour components.

Buying out of escalation
Fabricated equipment—usually possible to negotiate fixed prices for the life of the order without paying a premium. Mechanical equipment—sometimes as for fabricated equipment, sometimes necessary to pay about 0.8 to 0.9% per month.

ITALY

Quoted Prices—Usually subject to escalation.

Type of escalation formula—

$P_1 = P_o (0{\cdot}10 + a\, M_1/M_o + b\, L_1/L_o)$

where

- P_1 = Final Total Price.
- P_o = Quoted Price.
- M_1 = Weighted average of the material price indices shown in the "Listino dei Prezzi" of the magazine "L'Industria Meccanica (official monthly publication of the A.N.I.M.A.) normally during the first two-thirds of the order period. (Note that sometimes two or more material indices are used together.)

PRICE ADJUSTMENT PRACTICES (Continued)

M_o = Material index last published at date of quotation.

L_1 = Weighted average of the minimum hourly rates for a 3rd category mechanical skilled worker as published in L'Industria Meccanica " normally during the last two-thirds of the order period.

L_o = Hourly rate last published at date of quotation.

a and b are coefficients depending on the division of the price into material and labour components.

Buying out of escalation
Sometimes possible to buy out at approximately 1 to 1½% per month, or alternatively to fix a "ceiling" percentage and use the formula.

JAPAN

Quoted Prices—Usually firm and not subject to escalation through the life of the order, except for Copper and Nickel materials, where price variations are based on official international price levels.

SOUTH AFRICA

Quoted Prices—Usually subject to escalation.

Type of escalation formula—

$$P_a = P_q/100\ (10 + l\ L_q{-}2/L_q + m\ M_q{-}2/M_q$$

where

- P_a = Adjusted contract price.
- P_q = Quote Price.
- l = Percentage of quoted price to be adjusted for material cost changes (Common percentage is 55%).
- L_q = SEIFSA Index of Actual Labour Cost (All Hourly Paid Employees) at date of quotation.
- L_q-2 = Similar index at a date two months prior to the date when goods are ready for despatch.
- m = Percentage of quoted price to be adjusted for material cost changes (Common percentage is 35%).
- M_q = Relevant price index and/or price of materials at date of quotation (example — ISCOR Steel Price Index).
- M_q-2 = Similar index or price at a date two months prior to the date when the goods are ready for despatch.

Buying out of escalation
Possible, but very expensive and not recommended as an alternative to open escalation by formula.

U.K.

Quoted Price—Usually subject to escalation.

Type of escalation formula

$$V = C\ [A\ (L_2 - L_1)/L_1 + B\ (M_2 - M_1)/M_1]\ (1-F)$$

The most common formula as shown below is that established by the B.E.A.M.A. (British Electrical & Allied Manufacturers' Association). Although originally designed for the electrical industry it is now used by "mechanical" industries for which material and labour indices are also available.

where

- V = Value of CPA (Contract Price Adjustment) claim.
- C = Contract price.
- A = Weighting allocated to labour.
- B = Weighting allocated to materials. Note: A + B = 1.00.
- L = Appropriate BEAMA labour indices (Department of Employment).
- M = Appropriate material indices (Department of Trade and Industry).
- F = Amount of fixed element in formula.

Buying out of escalation
Possible, but difficult and can cost up to 2% per month. Alternatively possible to negotiate ceiling escalation percentage.

U.S.A.

Quoted Prices—Usually subject to escalation.

Type of escalation formula—

$$EP = OP\ (a\ M_2/M_1 + b\ L_2/L_1)$$

where

- EP = Escalated price.
- OP = Original quoted price.
- M2 = Material wholesale price index (four digit industrial class) (published monthly by Bureau of Labor Statistics), at date of shipment.
- M1 = Similar index at date of quotation.
- L2 = Average hourly earnings (standard industrial code) (published monthly by Bureau of Labor Statistics), at date of shipment.
- L1 = Similar index at data of quotation.

a and b are percentages for material and labor portions of total price.

Buying out of escalation
Possible, but very expensive (can be up to 20%) and not recommended as alternate to open escalation with formula.

(From July/August, 1977 American Association of Cost Engineers Bulletin)

APPENDIX E

SCALEUP EXPONENTS FOR SELECTED EQUIPMENT

Scaleup Exponents for Selected Equipment

Equipment	Scaleup Basis	Exponent f
Boilers, packaged complete, to 250 psig	Steam capacity: 1000 lb/hr	0.70
Boilers, field erected complete, to 400 psig	Steam capcity: 1000 lb/hr	0.80
Cooling towers, field erected complete/pumps, basin cooling range, 15° F	GPM	0.60
Coolers, air; field erected complete /motor; supports	sq.ft. area; (Calc. Area/15.5)	0.80
Heaters, direct fired 500 psig, c.s. tubes field erected	Absorbed heat, Btu/hr Also see Figure 5-9	0.85
Heaters, process furnaces 500 psig, c.s. tubes	Absorbed heat, Btu/hr	0.85
Process gas compressors; /drivers; to 1000 psig; applies to centrifugal and reciprocating types	Brake Horsepower	0.82
Pumps, centrifugal with driver; complete	(GPM) (PSI)	0.70
Tanks, storage; to 40,000 gal.; tank only vertical API conical light gage	Gallons Gallons	0.30 0.28
Tanks, storage; above 40,000 gal.; vertical cone roof, field erected	Gallons	0.63

Scaleup Exponents for Selected Equipment (Cont'd)

Equipment	Scaleup Basis	Exponent f
Refrigeration, mechanical, erected; complete, with centrifugal compressor	Tons refrigeration	0.70

Example: Find the cost of a 40,000 gal. cone roof tank. A recent bid for a 20,000 gal. cone roof tank was $35,000.

Thus, size ratio $= \frac{40{,}000 \text{ gal}}{20{,}000 \text{ gal}} = 2.0$

Assume: Capacity-cost exponent F = 0.45
Therefore, Cost Ratio = $(2.0)^{0.45} = 1.336$
Estimated cost of 40,000 gal tank:

$35,000 x 1.336 = $46.760

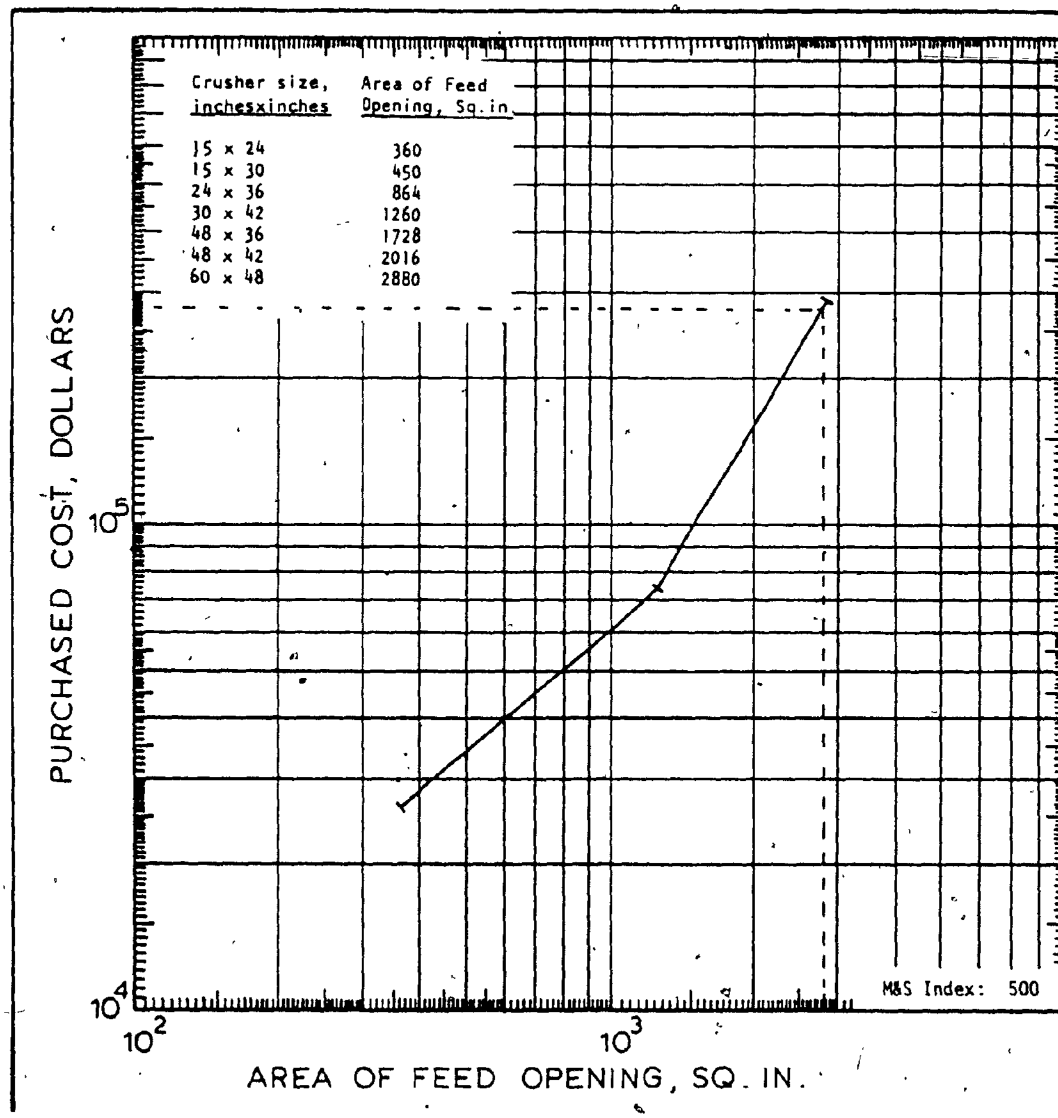
APPENDIX F

MAJOR PROCESS EQUIPMENT COST CURVES

The cost curves of some of the major process equipment were obtained from "Handbook of Major Equipment Costs for Factored Capital Cost Estimations" by A.L. Mullar, published by The Canadian Institue of Mining and Metallurgy, 1978.

The cost curve information has been supplied and verified by many major equipment firms and engineering consultant firms in the process industry at the time of writing (October, 1977). Thus, inflation rate variation has to be taken into consideration to obtain equivalent cost at present-day rate.

Estimated prices of equipment costs given in this handbook are approximations and must bot be considered quotations from any particular company or manufacturer.

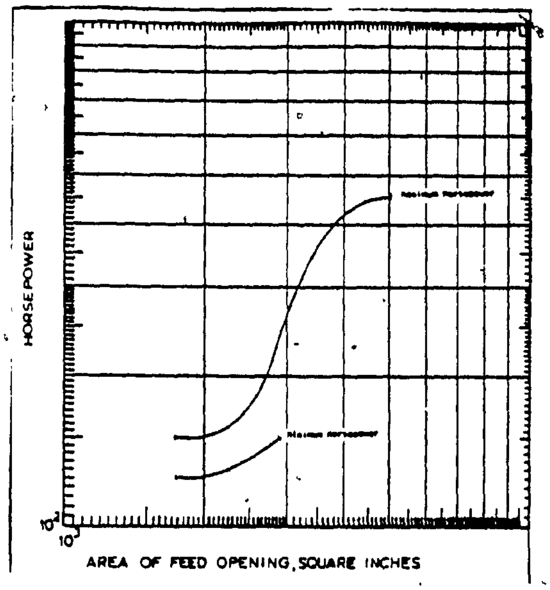


Jaw Crusher Costs. Price includes drive; excludes motor

<u>NOTE</u>: The cost of crushing machinery has been related graphically to the dimensions most commonly used when referring to a particular crusher. Graphs which relate size to horsepower and size to capacity have been included so that, given a size, horsepower, or a capacity requirement, cost of the equipment can be found.

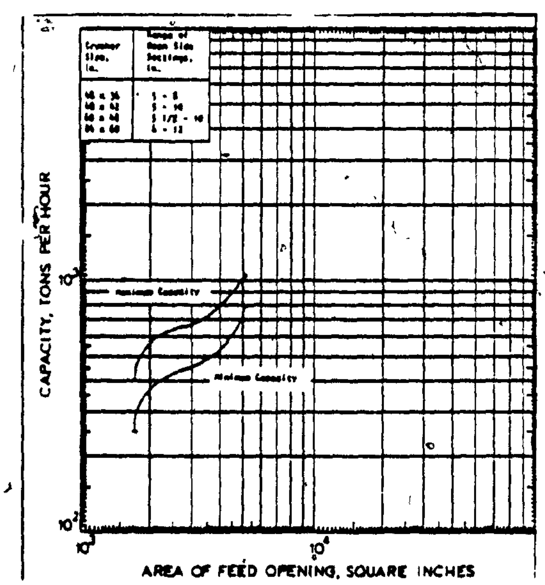
(From "Mineral Processing Equipment Costs and Preliminary Capital Cost Estimations, by A.L. Mullar. Published by the Canadian Institute of Mining and Metallurgy 1978).

Other equipment for crushing and grinding are included with graphs for similar purposes. Example: The area for a 60 x 48 jaw crusher is 2880 $in.^2$. Thus, the cost of this unit is $290,400.

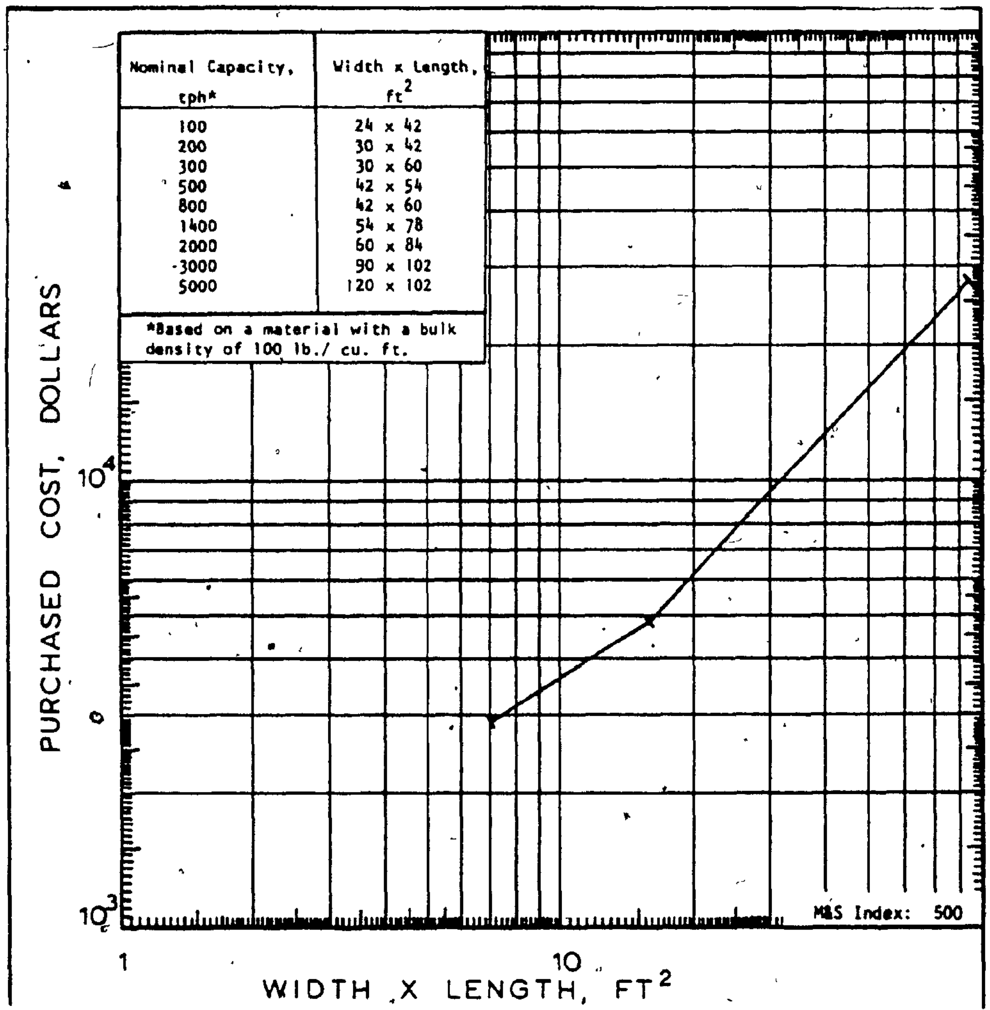


Jaw Crusher Horsepower Requirements

All cost in this appendix is based on the price of the equipment purchased in Canadian funds. At the time of the writing (October, 1977) the exchange rate in use was $1.00 Can.=0.93 U.S. A correction should be applied if this exchange rate varies.

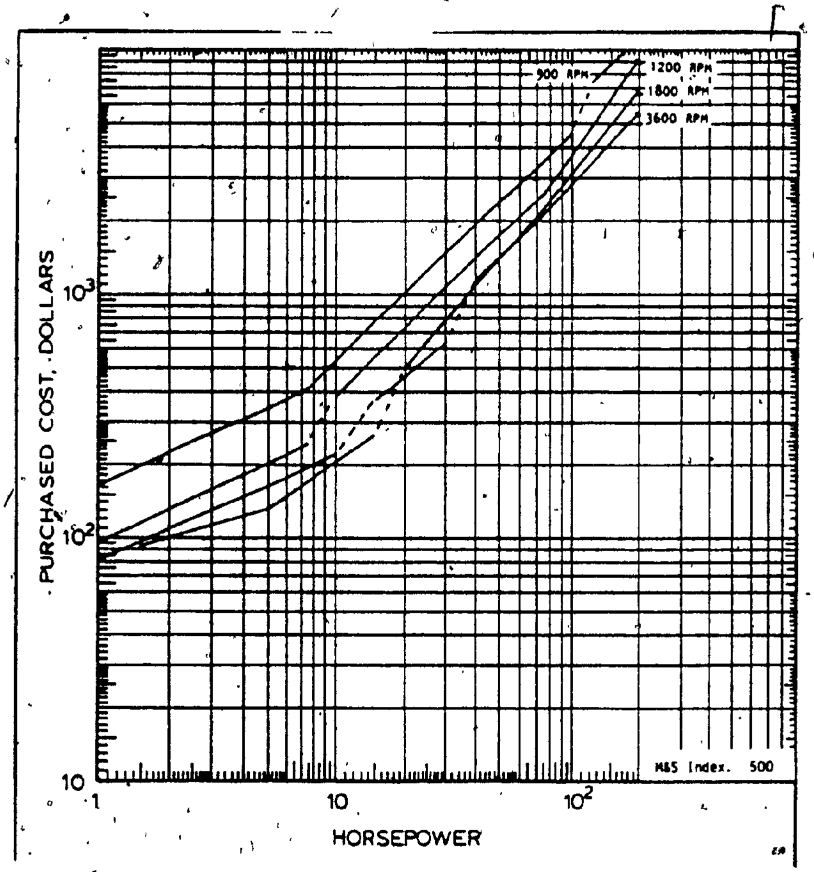


Jaw Crusher Capacities

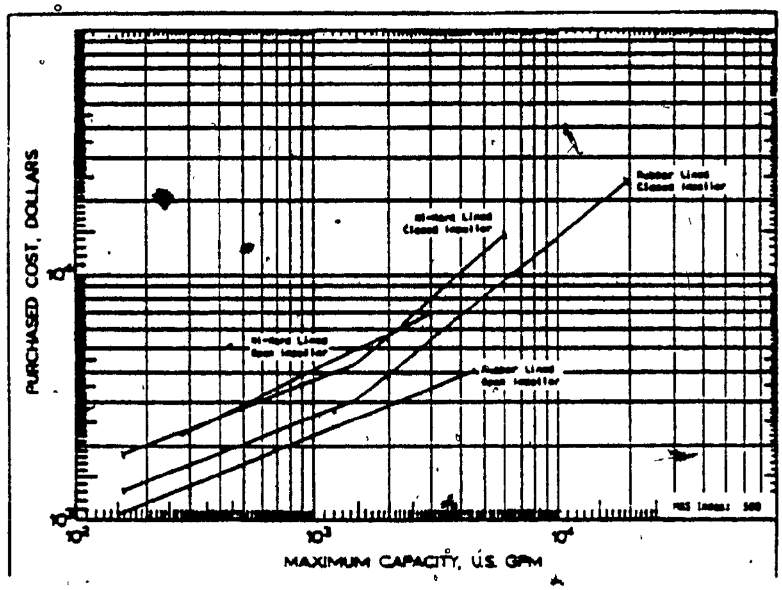


Vibrating Feeder Costs.*

* Include Motor and Drive

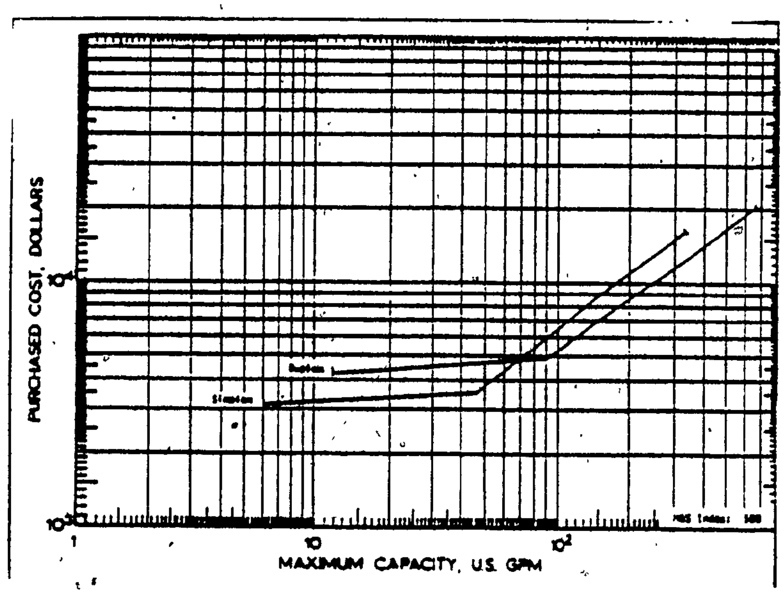


TEFC Motor Costs

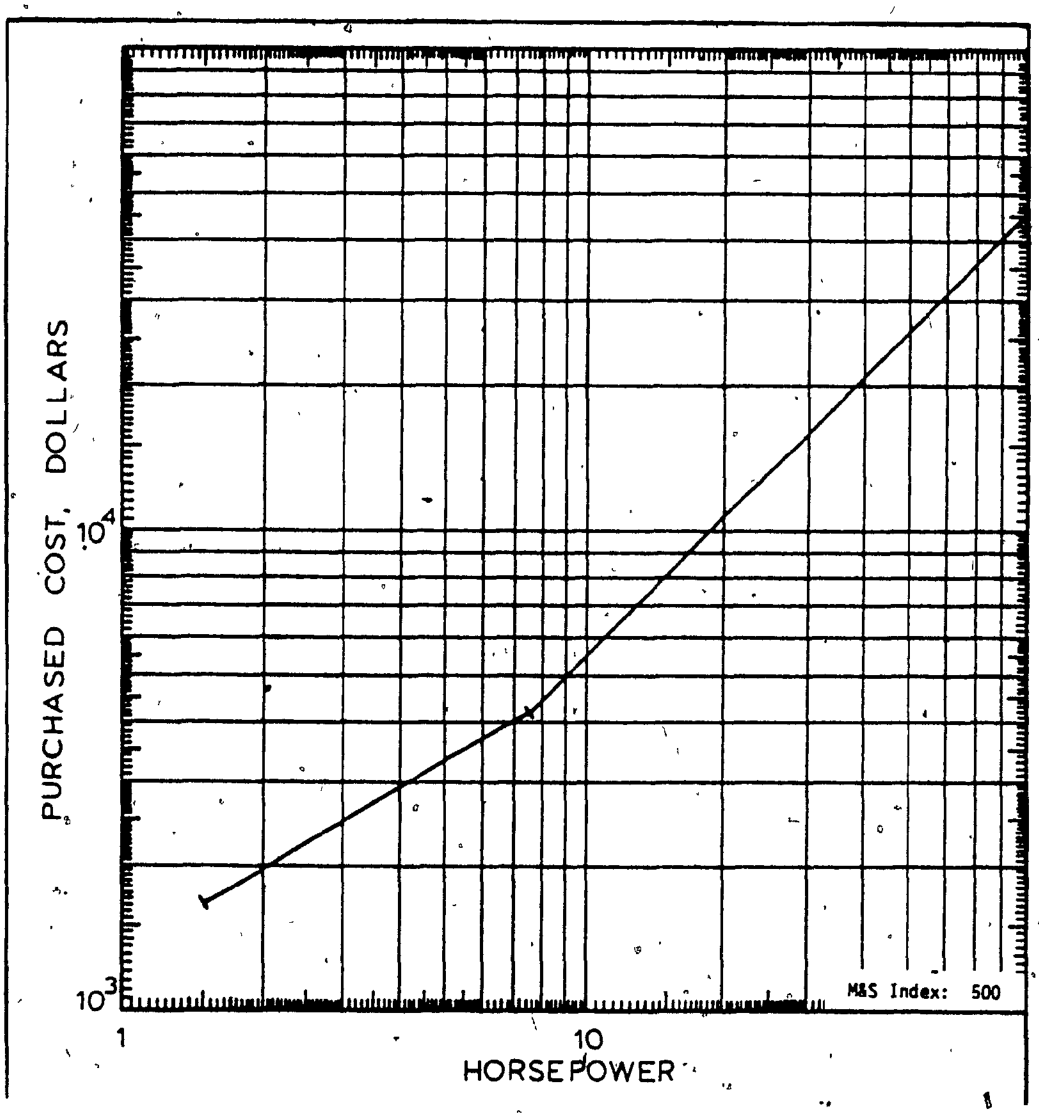


Horizontal Slurry Pump Costs*

* Cost exludes motor and drive, includes motor base and guard.

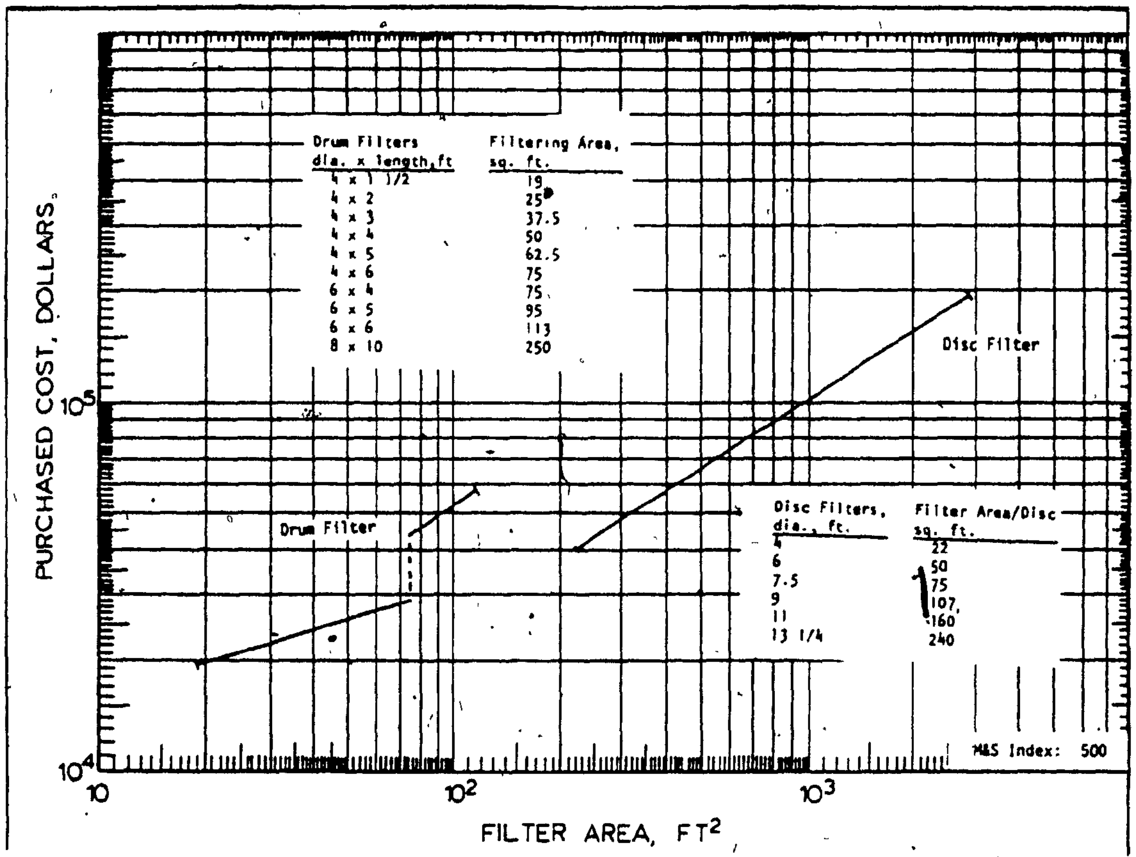


Diaphragm Slurry Pump Costs.

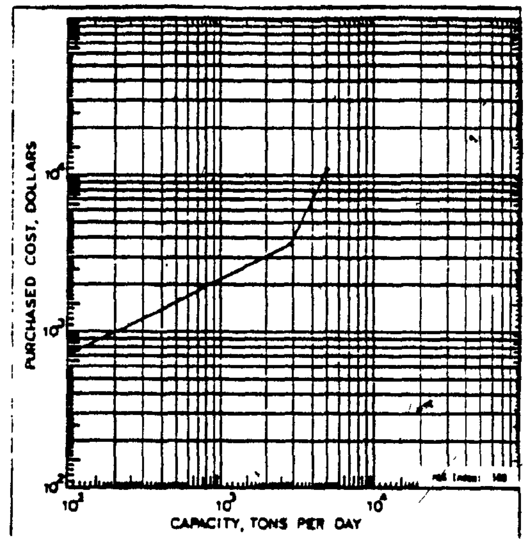


Agitator Mechanisms Costs.*

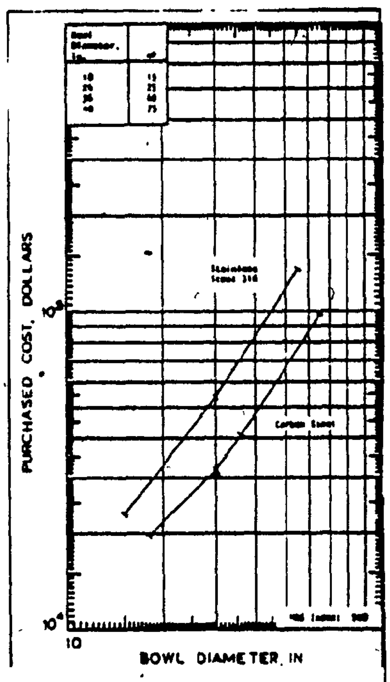
* Cost includes Propeller, Mechanism and Motor.



Drum and Disc Filter Costs.

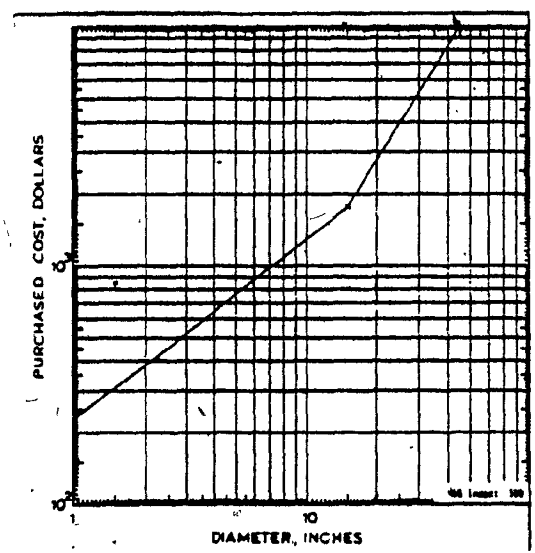


Wet Cyclone Costs
versus Capacity

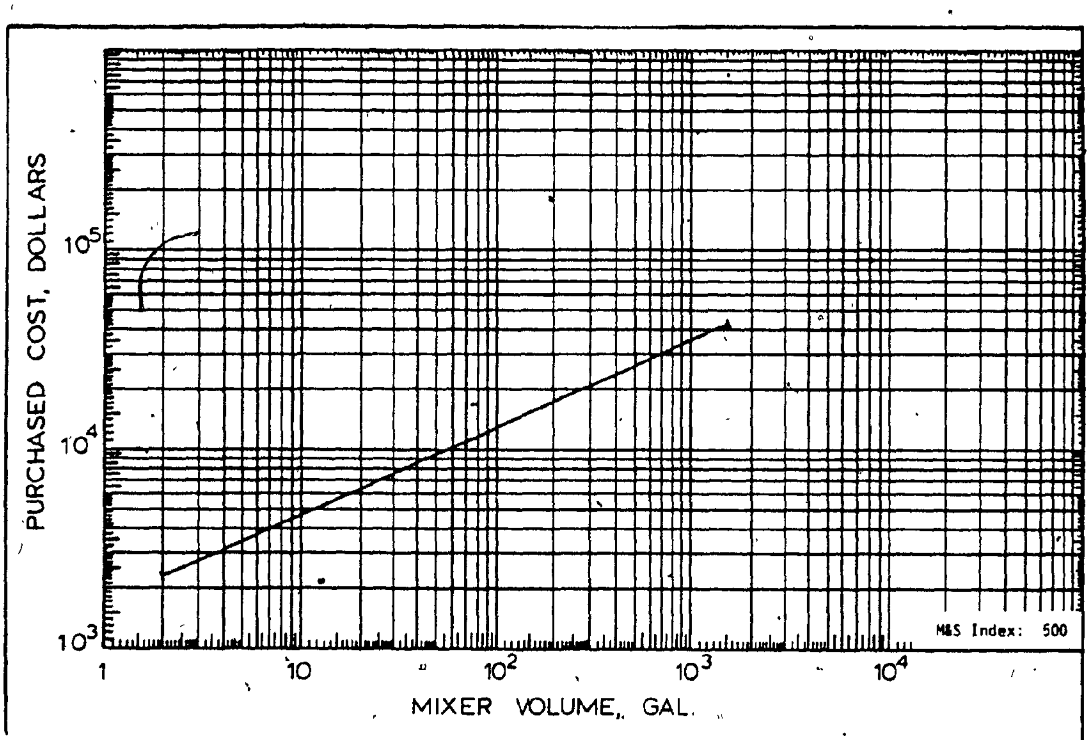


Centrifugal Filter Costs.*

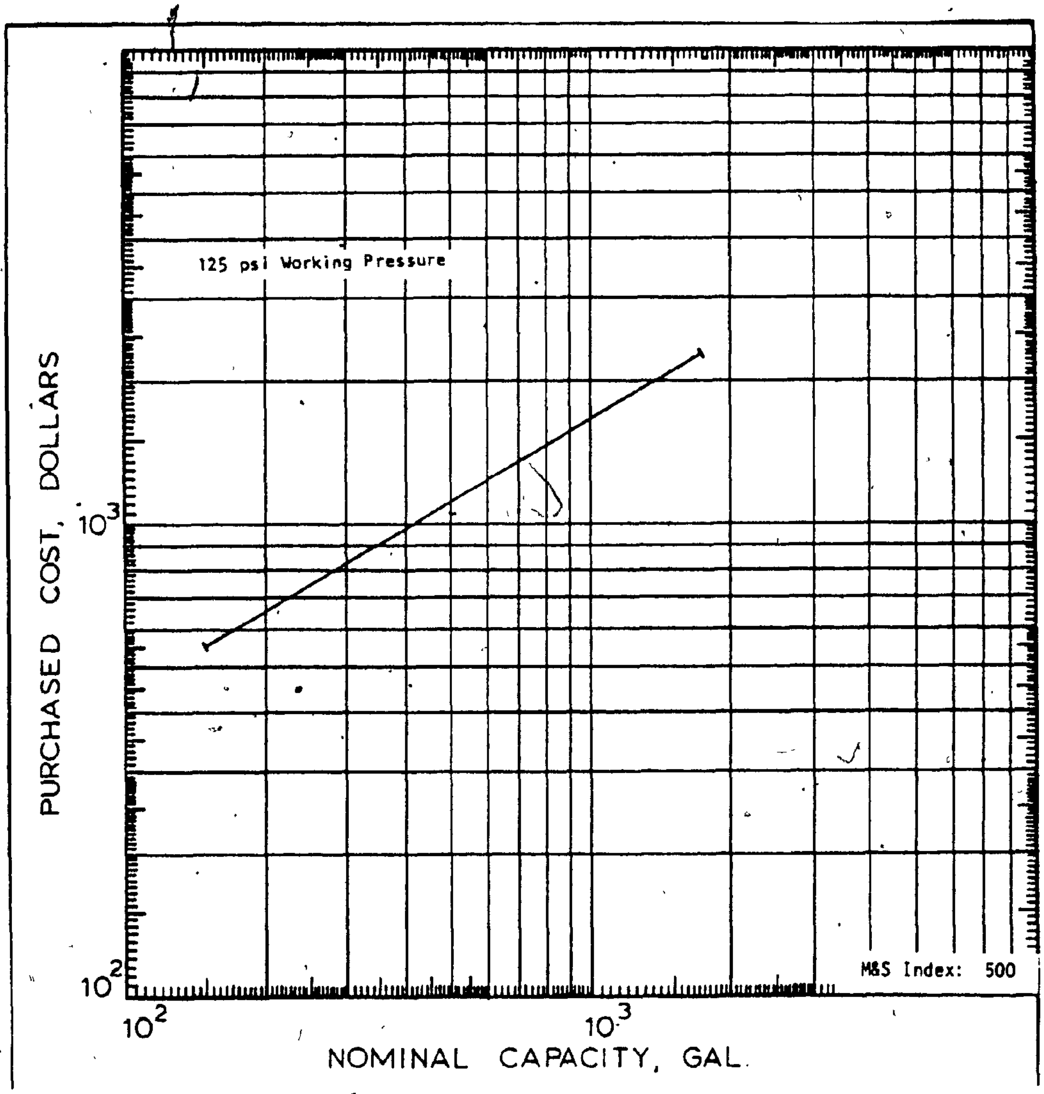
* Cost exludes motor and drive.



Wet Cyclone Costs
versus Diameter



Mixer-Settler Costs.



Pressure Vessel Costs.

Belt Conveyors

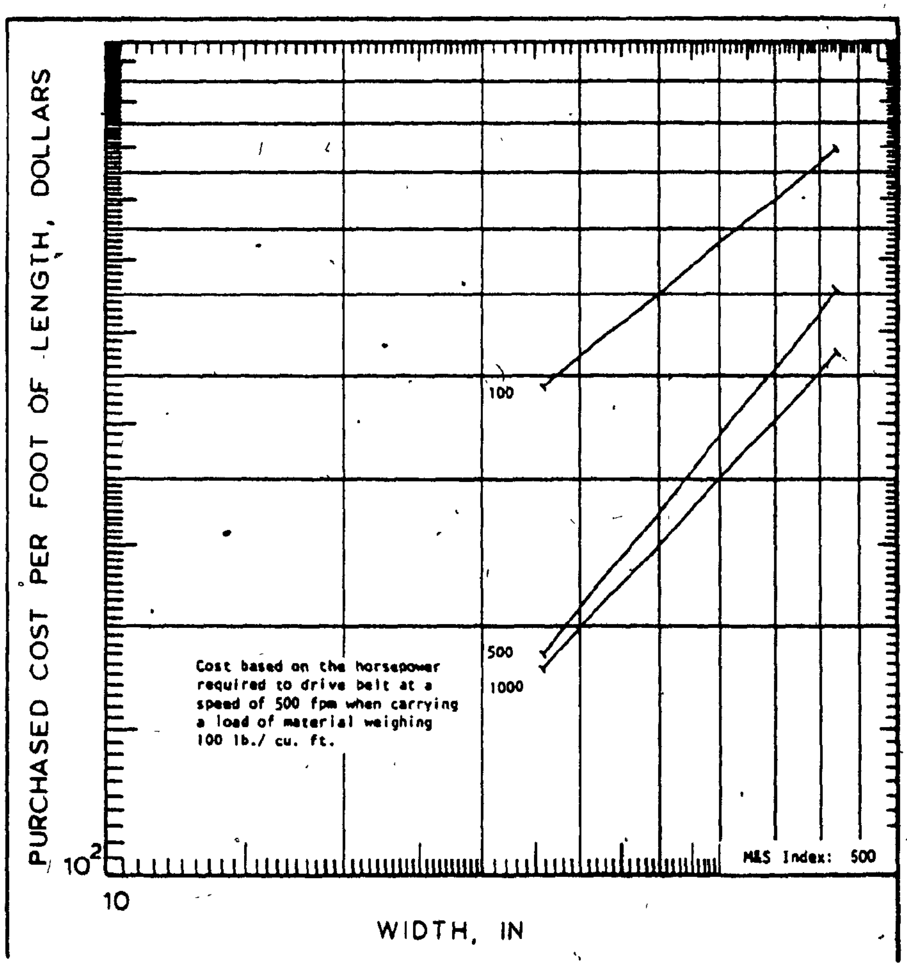
COST PER FOOT OF LENGTH = $a(X)^b$, in dollars

where X is the width of belt, inches.

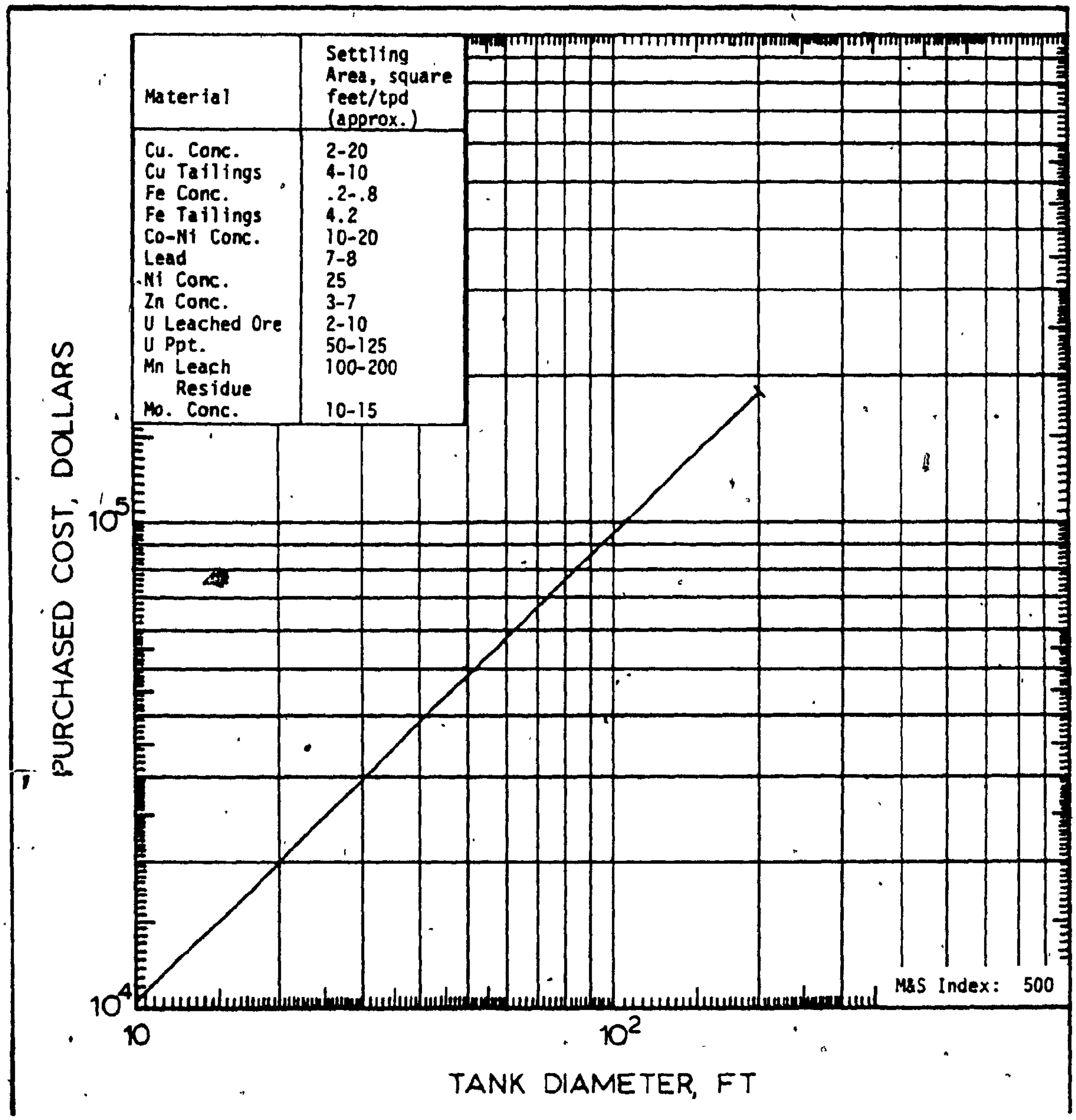
Length of belt, ft.	Range, width of belt, in.	a	b
100	36-84	23.9	.778
500	36-84	2.66	1.18
1000	36-84	4.47	1.03

Cost includes idlers, head-end drive, head frame, pulleys, gravity take-up on tail pulleys, belting, and simple ground mounted steel structure.

Estimation covers conveyors carrying a material weighing 100 lb./cu.ft., with a surcharge angle of 20°, at a belt speed of 500 fpm.



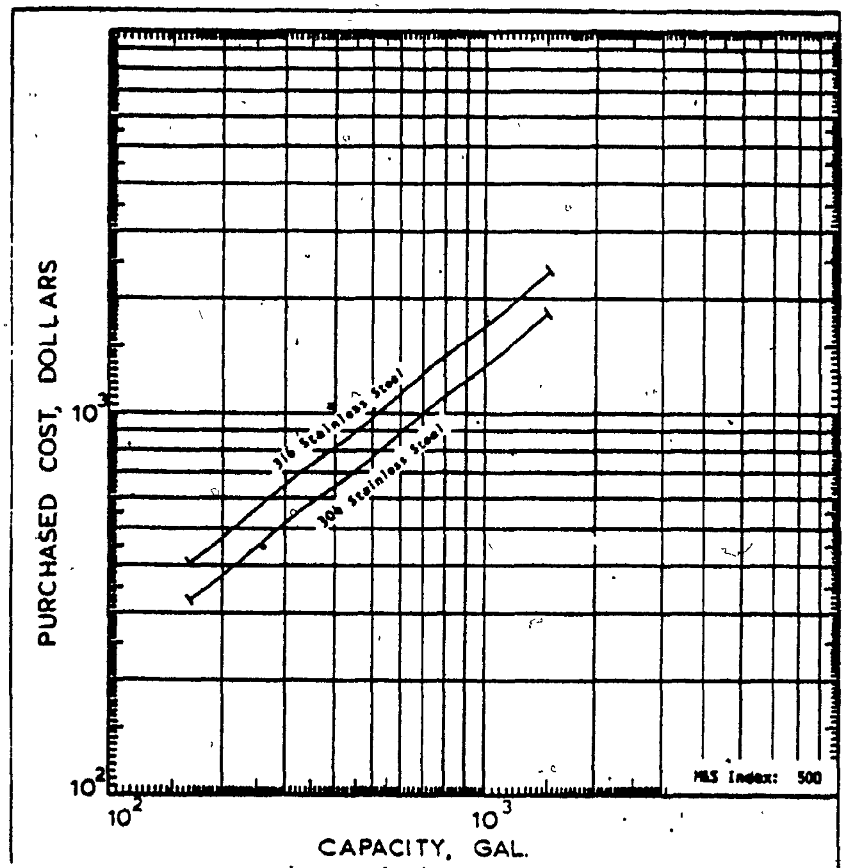
Belt Conveyors Costs



Material	Settling Area, square feet/tpd (approx.)
Cu. Conc.	2-20
Cu Tailings	4-10
Fe Conc.	.2-.8
Fe Tailings	4.2
Co-Ni Conc.	10-20
Lead	7-8
Ni Conc.	25
Zn Conc.	3-7
U Leached Ore	2-10
U Ppt.	50-125
Mn Leach Residue	100-200
Mo. Conc.	10-15

Thickener mechanism Costs.*

*Cost includes thickener mechanism, excludes tank.



NOTE: Another most widely-used method of estimating metal tank cost is by calculating the tank's weight* and from its weight, obtain the tank's cost.

Example: Estimate the cost of a reactor tank with the following preliminary information:

It was fabricated with 316 s.s., diameter: 8'0", height = 9'0"
Top and Bottom Ring Angles 3 x 3 x 1/4, Rubber Lining and Acid Brick Lining; 4 interior Baffles;

π x 8'0" x 9'0" Wall = Bottom area = 50 ft^2 @ 5/16" thick
= 640 lbs. (i.e., 12.8lbs/ft^2)

Wall area 226 ft^2 @ 12.8 lbs/ft^2 = 2880 lbs
Top & Bottom Ring Angles 3 x 3 x 1/4" = 2 x (π x 8')
= 50' @ 5 lbs/ft
= 250 lbs.

4. Interior Baffles 1.6' x 9' x 3/8" = (1.5 x 9) x 4 @ 15 lb/ft
   (approximate weight for 3/8" thick)

   = 810 lbs.

Thus, total weight of tank		4580 lbs
add wastes, parts, etc., @ 12%		520 lbs
	Use	5000 lbs

For 316 S.S. tank, approximate price per poind is $U.S. 3.00/lb (Jan. 80)

Cost of tank (exclude Rubber and Acid Brick lining):

5000 lbs @ 3.00/lb = 15,000

Rubber interior lining	(50 + 226) ft^2 @ 12.00/ft^2	=	2,300
Acid brick lining	(50 + 226) ft^2 @ 25.00/ft^2	=	6,900
	TOTAL COST OF TANK		$24,200

(*) For better method to estimate process equipment's weight, refer to "Hydrocarbon Processing", September 1979, by Mustafa El-Rifai.

APPENDIX G

PRESENTATION OF CAPITAL COST ESTIMATE AND ITS RELATED RISK ANALYSIS

The attached forms are recommended to be used for presentation of Capital Cost Estimate and its related Risk Analysis:

Form A-1: Presentation of Cost Estimate for equipment and material

The format is tailored to include related information which will help to assess the qualitative and quantitative nature of the recommended firm price proposal for the supply of equipment and material.

Form A-2: Risk Analysis for equipment and material

a) A check list of sources of risks are listed for guidance
b) The "most likely" column covers generally what was included in the realistic cost estimate
c) The "most pessimistic" column would generally include probable overruns under the worst cases
d) The "most optimistic" column would include probably overruns as well as probable underruns under the best cases. A negative sign should be used for probably underruns.

Form A-3: Summary of Risk Analysis for equipment and material

a) The exposure in the worst case, the most likely exposure, and the exposure in the best case are the respective differences between the total exposure as analyzed and the amount available in the estimate to compensate such exposure.

b) The exposure in the worst case is the gap needed to add (or deduct) in order to approximately break even under the most pessimistic conditions. This gap or a part of it depending on the marketability of the proposal is the recommended "Risk Factor" added (or deducted) from the total price, as per management decision.

Form B-1: Presentation of Cost Estimate for home office service

The format is tailored to include related information which will help to assess the qualitative and quantitative nature of the recommended firm price for the services carried out in the home office.

Form B-2: Risk Analysis for home office services

Same as 5.3.2 above.

Form B-3: Summary of Risk Analysis for home office services

Same as 5.3.3. above.

PROPOSAL : ....
LOCATION : ....
DATE : ....

FORM A-1
PAGE 1

PRESENTATION OF
COST ESTIMATE FOR EQUIPMENT AND MATERIAL — **IN $ 1000**

BASIC PURCHASE COST		....
- Scope Definition	: .... % clear	
- Validity Date:		
- Firm Quotations received	: .... %	
- Budget Quotations received	: .... %	
- Estimated	: .... %	
- Delivery Duration	: .... Months	
COST ESCALATION BEYOND VALIDITY DATE		....
- Amount Subject	: .... %	
- Applicable Duration	: .... Months	
- Estimated Rate	: .... % per Yr.	
CONTINGENCIES		....
- Design Contingency	: .... %	
- Process Changes	: .... %	
- Allowance for undefined items	: .... %	
INCIDENTAL COSTS		....
- EDC Insurances	: $.........	
- Bank Guarantees	: $.........	
- Performance Bonds	: $.........	
- Cost of Letters of Credit	: $.........	
- Other Insurances	: $.........	
- Cost of Proposal	: $.........	
- InHouse Financing	: $.........	
- Agent Fees	: $.........	
- Other (Specify)	: $.........	
ADDITIONAL FINANCIAL CHARGES (EDC Services)		....
- Rate	: .....%	
RECOMMENDED PROFIT		....
- Rate	: .....%	
NEGOCIATION MARGIN		....
RISK FACTOR (As per Summary Risk Analysis - Form A-3)		....
	TOTAL PRICE	....

REMARKS:

PROPOSAL : ....
LOCATION : ....
DATE : ....

FORM A-2
PAGE 1

IN $ 1000

SOURCES OF RISKS	MOST PESSIMISTIC	MOST LIKELY	MOST OPTIMISTIC
- Cost over/underrun of Firm Quotations $............ x ....%, x ....%, x ....%			
- Cost over/underrun on Budget Quotations $............ x ....%, x ....%, x ....%			
- Cost over/underrun on Estimated Amounts $............ x ....%, x ....%, x ....%			
- Cost over/underrun on Estimated Quantities			
- Misinterpretation of Scope Description by Vendors.			
- Possible Process and Design Changes $........x....%, x ...%, x ....%			
- Exposure on New Technology			
- Possible Duplication of Listed Items			
- Exposure on Environmental Items			
- Back to Back Guarantees for .... additional months. $............ x....%, ...%			
- Impact on Job of Damaged Equip/Mat.			
- Handling of "No Good" Equip/Mat.			
- Cost Escalation due to delayed purchase orders. ....Mos x ....% per Yr.			
- Cost over/underrun due to overseas procurement. $............ x ....%, ...%			

FORM A-2
PAGE 2

SOURCES OF RISKS	IN $ 1000 MOST PESSIMISTIC	MOST LIKELY	MOST OPTIMISTIC
- Port delays, additional storage charges.			
- Extra Costs due to Joint Venture Interfacing.			
- Foreign Exchange Fluctuations. $.......... x ....%, x ....%			
- Impact of schedule changes. ....Mos x $.............			
- Additional Financing due to Potential negative cash flow burdens. $.......... x ......Mos x ....% per Yr.			
- Possible Loss of Interest due to delayed payments. $.......... x ......Mos x ....% per year			
- Possible Import duties, taxes $.......... x ....%			
- Negociation margin			
- Exposure on delay penalties $.......... x ....% chance, ...% chance			
- Exposure on Performance Bond $.......... x ....% chance, ...% chance			
- Loss of Holdback			
- Other Risk Exposure			
TOTAL EXPOSURE :	....	....	....

PROPOSAL : ....
LOCATION : ....
DATE : ....

FORM A-3
PAGE 1

SUMMARY OF RISK ANALYSIS FOR EQUIPMENT AND MATERIAL	IN $ 1000 MOST PESSIMISTIC	MOST LIKELY	MOST OPTIMISTIC
Total Exposure (From A-2)	....	....	....
Amount available in Estimate to compensate total exposures			
Contingencies :			
Recommended Profit :			
Negociation Margin :			
Other Anticipated Profit :			
....	....	....	....
Exposure in the Worst Case	....		
Most Likely Exposure		....	
Exposure in the Best Case			....
Recommend to use a "Risk Factor" of	....	....	....
Profit in the Worst Case	....		
Most Likely Profit		....	
Profit in the Best Case			....

REMARKS:

FORM B-1
PAGE 1

PROPOSAL: ....
LOCATION: ....
DATE : ....

PRESENTATION OF

COST ESTIMATE FOR HOME OFFICE SERVICES

GENERAL INFORMATION

- Date of contract start : ....
- Total Duration of Services : .... Months
- Duration of Engineering : .... Months
- Number of Estimated Drawings (equivalent size) : .... Drawings
- Services Manhours
  - Project Management : .... Manhours
  - Project Management Services : .... Manhours
  - Engineering : .... Manhours
  - Procurement : .... Manhours
  - Construction : .... Manhours
  - Commissioning/Training : .... Manhours

Total: .... Manhours

- Recommended mark up: ....

	IN $ 1000
SALARY COST AS OF	....
- Average : .... $ per Manhour	
COST ESCALATION	....
- Applicable Duration : ......Months (To center of gravity of activities)	
- Estimated Rate : .....% per year	
Subtotal Salary Cost	..............(1)
SALARY ADDITIVES	..............(3)
- Fringe Benefits on (1) :....% (2)	
- Company Overhead on (1) and (2):....%	
RECOMMENDED PROFIT	
- Rate ....% on (1) and (3)	....
Subtotal marked up salaries	....

FORM B-1
PAGE 2

HOME OFFICE EXPENSES ....

- Administration .....% included

CONTINGENCIES ....

- On marked up salaries : ....%
- On Home Office expenses : ....%

INCIDENTAL COSTS ....

- EDC Insurances : $............
- Bank Guarantees : $............
- Performance Bonds : $............
- Cost of Letters of Credit : $............
- Other Insurances : $............
- Cost of Proposal : $............
- In-house financing : $............
- Agent Fees : $............
- Other (Specify) : $............

ADDITIONAL FINANCIAL CHARGES (EDC Services) ....

- Rate : .....%

NEGOTIATION MARGIN ....

RISK FACTOR (As per Summary of Risk Analysis-Form B-3) ....

TOTAL PRICE: ....

REMARKS:

FORM B-2
PAGE 1

PROPOSAL: ....
LOCATION: ....
DATE : ....

RISK ANALYSIS FOR HOME OFFICE SERVICES

IN $ 1000

SOURCES OF RISKS	MOST PESSIMISTIC	MOST LIKELY	MOST OPTIMISTIC
- Cost Over/Underrun on Estimated Manhours $............ x ....%, x ....%, x ....%			
- Cost Over/Underrun on Estimated Salaries $............ x ....%, x ....%, x ....%			
- Cost Over/Underrun on Estimated Number of Drawings ..../.... Drwgs x .....Mhrs/Drwg x $...../Mhr.			
- Above/Below normal Salary Cost Escalation ....% instead of ....%, ...% instead of ....%			
- Added/Reduced Engineering on Vendor-Engineered Items.			
- Exposure on New Technology			
- Impact of Extra Normal Client Coordination			
- Impact of Lack of Decisions & Delays in approvals			
- Impact of Schedules Changes on Manhours ......Mos x $............			
- Extra Costs due to Joint Venture Interfacing			
- Cost Over/Underrun on Home Office Expenses $........... x ....%, x ....%, x ....%			
- Foreign Exchange Fluctuations $........... x ....%, x ....%			

FORM 8-2
PAGE 2

IN $ 1000

SOURCES OF RISKS	MOST PESSIMISTIC	MOST LIKELY	MOST OPTIMISTIC
- Additional Financing Due to Potential Negative Cash Flow Burdens. $........... x ......Mos x ....% per year.			
- Possible Loss of Interest Due to delayed payments. $........... x ......Mos x ....% per month			
- Negociation Margin			
- Exposure on Delay Penalties $........... x ....% chance, ...% chance			
- Exposure on Performance Bond $........... x ....% chance, ...% chance			
- Loss of Holdback			
- Other Risk Exposures			
TOTAL EXPOSURES:	....	....	....

FORM B-3
PAGE 1

PROPOSAL: ....
LOCATION: ....
DATE : ....

IN $ 1000

SUMMARY OF RISK ANALYSIS FOR HOME OFFICE SERVICES		MOST PESSIMISTIC	MOST LIKELY	MOST OPTIMISTIC
TOTAL EXPOSURE (From B-2)		....	....	....
Amount available in Estimate to compensate total exposure:				
Contingencies	:			
Recommended Profit	:			
Negotiation Margin	:			
Other Anticipated Profit	:			
	....	....	....	....
Exposure in the Worst Case		....		
Most likely Exposure			....	
Exposure in the Best Case				....
Recommend to use a "Risk Factor" of		....	....	....
Profit in the Worst Case		....		
Most Likely Profit			....	
Profit in the Best Case				....

REMARKS: