SUBCONTRACTING BY THE PETROCHEMICAL ENGINEER-CONSTRUCTOR

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ABSTRACT

An analysis has been made of the methods used by a Petrochemical Engineer-Constructor, who has national labor agreements, in deciding if the construction phase of a project should be done by a subcontract method of construction or be accomplished on a direct hire basis. The petrochemical complex under discussion is considered to be in the $75 million range for the total installed cost including design, engineering, procurement, and construction.

The influence of subcontracting portions of the construction phase by the Engineer-Constructor is reviewed with its impact on: the client; project schedule and cost; local and national labor relations, because of the use of local versus national subcontractors; methods of engineering; and traditional methods of construction philosophies of both the client and the Engineer-Constructor. An Engineer-Constructor's method of deciding if work should be subcontracted and the method of subcontract preparation is analyzed with the purpose of establishing an improved system.

It was established that the present policies used in making the decision to subcontract construction work by the Engineer-Constructor, although they may need improvement, are compatible to obtaining the most economical complex for the client and obtaining the optimum profit for the Engineer-Constructor. With certain recommended changes in procedure the speed at which the subcontracts may be issued can be increased.

APPROVAL OF THESIS

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GLOSSARY OF TERMS

Bidder	The firm that is quoting to the Engineer-Constructor for award of a subcontract.
Bid Tabulation	Document made by the Procurement Department of the Engineer-Constructor of the potential subcontractors quotations used for evaluation purposes.
Client	Owner of the petrochemical complex who has the contract with the Engineer-Constructor.
Company	The Engineer-Constructor.
Complex	Petrochemical unit to be built for the Client by the Engineer-Constructor. Estimated size of $75,000,000.
Construction Manager	Individual assigned by the Engineer-Constructor who has responsibility for the field construction of a project who reports to the Project Manager.
Contract	Agreement between the Client and the Engineer-Constructor for the complex.
Direct Hire Method	Method used by the Engineer-Constructor for construction of a complex by which no subcontracts are issued.

Engineer-Constructor	A member of the National Contractors Association who takes the prime contract for all or part of the research and development, design, procurement, and construction of petrochemical complexes throughout the United States.
Inquiry	Document issued by the Engineer-Constructor to potential Subcontractors stating work which the Engineer-Constructor wants to be performed.
Invitation to Bid	Document issued to selected Engineer-Constructors stating the Client's requirements for a Petrochemical Complex and requesting methods and costs for execution.
P & I Diagram	Piping and Instrument Diagrams-Drawings indicating the required design criteria for a complete piping and piping instrumentation system.
Prime Contractor	Engineer-Constructor, the firm having the contract responsibility to the Client.
Process Flow Diagrams	Drawings indicating process requirements for the complex. The basis of the P & I Diagrams.
Project Manager	The Engineer-Constructor's designated employee who is totally responsible for the engineering and construction of the Complex.

Proposal	Reply by the Engineer-Constructor to the Client as to how the Engineer-Constructor anticipates performing the work and the cost for performing the work stated in the Client's Invitation to Bid.
Subcontract	Agreement between the Engineer-Constructor and another Firm for work to be performed by the Firm.
Subcontractor	Firm performing work for the Engineer-Constructor.
Supervisor of Subcontracts	Individual responsible for issuance to the Procurement Department of the technical portion of a subcontract in a biddable form.
Supplement	Document issued by the Engineer-Constructor to the Subcontractor adding additional information into a Subcontract.
TIC	Total installed cost of a project including costs for engineering, procurement, and construction.
Utility Flow Diagrams	Same as Process Flow Diagrams but for the Utlity System of the complex.

I. INTRODUCTION

With the ever increasing demand for petrochemical based products since World War II, there has been a mushrooming demand for increased petrochemical technology in order to satisfy this demand and also develope the emerging nations of the world. As petrochemical based products more and more replaced the standard natural products, many companies involved in the research, development, engineering, and construction of the petrochemical complexes have seen an expansion which has hitherto been unknown.

The expansion in the petrochemical industry that the Engineer-Constructor has been forced to keep up with can be seen in Table I on page 2. This table indicates an increase of 150 to 350% in new plant capacity which has taken place since 1955 with the average capital expeditures increasing to approximately 400% of those in 1955.[1]

The rapid expansion in client requirements that has taken place in recent years has forced the Engineer-Constructor to expand his staff in order to meet this unprecedented demand. It has not been uncommon within the last three years for example, for a typical Engineer-Constructor to increase its staff from approximately 340 to a present staffing of over 1,000.

[1]"LTC-The Technical Center of a Technology Company" The Lummuscope, Volume 3, No. 1, January/February 1975, p. 2.

TABLE I

GROWTH IN THE PETROCHEMICAL INDUSTRY

	1955	1965	1975
World Petroleum Consumption bbls/day	13,954,000	28,774,000	57,008,000
Typical Capacity of new refinery bbls/day	80,000	100,000	200,000
Typical Capacity Large Ethylene Plant T/Yr	100,000	300,000	450,000
Typical Capacity Large Ammonia Plant T/Yr	120,000	300,000	450,000
TIC of Average Project $Mill.	15	30	75

It has been estimated that the world petrochemical market is growing at the rate of 10-12% per year,[2] with an estimate that $360 billion will be required for capital investments in the petrochemical field between 1970-1985.[3]

In order to attempt to keep up with this world demand, the refiners and producers of petrochemical products have attempted to expand their output by constructing new and larger facilities along with the revamping of their existing facilities.

[2]T.C. Ponder, "Petrochemicals-More for 1974, "Hydrocarbon Processing, May 1974, pp. 81.

[3]H. Hoffman, "Refiners Caught in the Middle, "Hydrocarbon Processing, May 1974, pp. 75-77.

Due to the new technology and in order to maintain competitiveness, it is no longer economical to build the small and medium size petrochemical complex. The complexes have grown now to mammoth proportions. Along with the growth of plant size, the costs have also mushroomed. In order for a producer of ethylene to build a new plant with the modern technology, the capital investment is estimated to be between $50 and $100 million.[4] Petrochemical and other energy complexes are anticipated to grow in cost to between $300 million and $1.5 billion per unit.[5]

An example of the anticipated growth in the petrochemical field has been expressed by F. McKay, Vice President and General Manager of the Fluor Engineers and Constructors of Los Angeles, when he stated:

> "We thought Mobil Oil's 164,000 bbls/day refinery in Joliet, Ill., was enormous, when we began. Now it's only an average size. No one can afford to think of 25,000 bbls./day increases. If you don't go for 100,000 bbls./day or more you're not thinking in the right terms."[6]

Although the typical engineering design life for a petrochemical complex may be as long as 20 years, the economical life of the plant process is far less than this unless a revamp or a modification of the process equipment is made in order to meet new process technology. If

[4]E.J. Basler, L.P. Hallee, and S.B. Zdonik, "How Feedstocks Affect Ethylene," Hydrocarbon Processing, February 1974, p. 75.

[5]"Boom for Contractors is a Mixed Blessing," The Oil and Gas Journal, June 3, 1974, p. 92.

[6]K. Brooks, "Is it Ready for a Building Boom," Chemical Week, March 21, 1975, p. 36.

this is not accomplished the owner may find that other refiners have surpassed him in technology and he is being squeezed out of the product market.

With this increase in demand for petrochemical products and technology, along with the large capital investments which are now required, there has developed a demand for a specialized type of constructor. This is the company that can be contracted by a client to not only build a complex in accordance with drawings and specifications, but to do the basic research and development, engineering, and procurement. By using this type of Engineer-Constructor, the client can attempt to eliminate the interface problems and associated costs which would normally be incurred if the process design, engineering, and construction were given to different firms. The responsibility for coordination of the various phases of the project would now be placed on one Engineer-Constructor for the optimum overall method of engineering and construction in order to minimize the client's costs.

Since the size, locations, and scheduling requirements are as varied as the products that the complexes will produce, there has developed a deep concern as to the method that the Engineer-Constructor will use to insure that the plant will be constructed within the time and cost criteria established by the client. The decision to subcontract or not to subcontract portions of the construction becomes a critical item. Although the construction phases of the project may not start for 3 to 5 years, the method in which the engineering and procurement will be accomplished by the Engineer-Constructor is effected by this decision. The philosophy to subcontract or not has been analyzed by many of the large Engineer-Constructors in the past few years with changing in corporate policies being the result.

As the projects become larger in size and longer in schedule, the available qualified staff of the Engineer-Constructor is gradually being spread thinner and thinner, as are the available trained labor forces which can be economically maintained by the Engineer-Constructor. As the Engineer-Constructor continually finds himself building projects from one coast to the other and working in many labor jurisdictions, there has developed a greater reliance on the use of subcontractors who are familiar with the local conditions and operate in these conditions on a daily basis, unlike the large petrochemical Engineer-Constructor who may be in an area on a one time basis.

The large growth of manpower requirements in the field construction of these petrochemical complexes has risen from the typical peak of 300-400 in the mid 1960's to a projected 2000-3000 for large projects in the mid 1970's and 1980's.

Along with this Engineer-Constructor development has developed the large specialized subcontractor. It is not unusual for the subcontractors on a petrochemical complex to approach the size of the Engineer-Constructor. Many of the specialized subcontractors have established separate divisions to handle only the power and process industries.

The subcontractors have developed the expertise in estimating, management, and labor relations that equal, if not surpass, the Engineer-Constructor, but in their own field. Where the Engineer-Constructor has National Labor Agreements, the subcontractor has his agreements with the locals and is familiar with the rank and file of the hiring halls. The subcontractors are able to work very closely with the specific locals in the areas of their expertise year in and year out, whereas the large national Engineer-Constructor may only come into an area on one project and then leave. The Engineer-Constructor has a difficult time developing a familiarity with the local, its people, or developing a firm feeling for the problems of the area.

The ties of the craftsmen tend to develop between the local subcontractors rather than the national Engineer-Constructor. As a result, there could develope a distinct difference in productivity received between the subcontractor who will work with the local men continuously, and the large outside Engineer-Constructor who may be leaving in a few years and never come back.

With the increasing numbers of large and small qualified subcontractors in many areas of the country, it has been found that there can be a decrease in the perminent staff of the Engineer-Constructor, especially on the general foreman and superintendent level, thus decreasing the Engineer-Constructor's overhead.

With the growth in size of the new complexes in the last decade the Engineer-Constructor has developed a more professional outlook on construction with more and more professional and graduate engineers entering the field.

There has entered into the construction industry, a greater concern for the legal responsibilities of the client and the constructors. Construction law has developed with many Engineer-Constructors obtaining, either on a perminent or temporary basis, contract and construction lawyers. This new aspect has been created in order to adapt to the responsibilities created by projects now becoming extremely complex and involving larger and larger sums of money, much of which is either being obtained from public stock and bond issues or indirectly being scrutinized by the Federal Government under various tax or labor laws.

There has been an attempt by some large Engineering-Constructors to get into the field of Construction Management. In doing so, they would subcontract out certain portions of the work to companies that had a greater expertise than they in certain specific areas. In general, although the primary responsibility is by the Engineer-Constructor, the subcontractor who works for the Engineer-Constructor would be accepting a great portion of the responsibility of a certain phase of the work. The subcontractor is paid for this transfer of responsibility. The party who is going to have to eventually correct a problem which may have developed due to faulty workmanship or product compatability has accepted and is being paid for this responsibility.

This would thus aid the client by eliminating the large contingency factor which the Engineer-Constructor must put in his bid to the client for phases of work for which he does not have expertise. Although the subcontractor must put in a contingency factor, it is usually smaller than that of a Engineer-Constructor.

There has developed within the petrochemical Engineering-Constructor profession an increase in the amount of work to be subcontracted for the above reasons. Companies which traditionally have done most of their work on a direct hire basis are now doing more and more investigating of the advantages of subcontracting portions of their work.

When a client has decided to invest the amount of capital required to build a new petrochemical complex, the selection of an Engineer-Constructor becomes extremely important. Toward this a select group of Constructors who can give a client not only the construction expertise, but also the engineering and many times the Research and Development aspects has been generated.

II. SCOPE OF WORK

The coordination of the design, engineering, procurement, and construction phases of a petrochemical complex is of paramount importance to a client who is investing hundreds of millions and sometimes even billions of dollars in the mammoth complexes of today. With only a minor error in coordination, hundreds of thousands of dollars may slip unrealized from the client, only to be discovered when the costs are irretrievable.

It is intended that this paper be written towards the large Engineer-Constructor, working in private industry, having National Labor Agreements, and working throughout the United States. The subcontracting methods and procedures used by this Engineer-Constructor for portions of a $75,000,000 complex will be analyzed, checking for benefits and possible pitfalls.

A comparison of the Company's use of direct hire personnel versus the use of subcontractors to construct the project will be made along with an analysis of the Engineer-Constructor's subcontracting procedures looking for the possibility of streamlining these procedures to obtain the most economical overall project.

The interrelation between the method which is used to schedule the engineering and construction of a complete turnkey project will be compared to the companies present policies and methods of construction, ie. doing the work on a direct hire or subcontract basis. The impact on both cost and schedule will be studied with the objective of establishing the most economical method of completing the project within the client's requirements.

The possibility of the national Engineer-Constructor competing in the local labor market versus the use of either local or national subcontractors to perform the work will also be reviewed.

The methods in which the subcontracts of the Engineer-Constructor are prepared and broken down by work scope will be compared with the possibility of issuing either a limited number of large subcontracts, a greater quantity of small subcontracts, or a mixture of subcontracts and doing the work on a direct hire basis.

III. CURRENT SUBCONTRACT PROCEDURES

At this point a short explanation of the relationship between the Engineer-Constructor and the client, and the type of prime contract which the Engineer-Constructors are working under is appropriate.

When the petrochemical Engineer-Constructor is bidding a project for a prospective client, he generally knows the competition and that it is limited. This comes from the fact that the expertise that is required to complete a particular type of petrochemical complex, with its associated engineering requirements, will be had by only a limited number of Engineer-Constructors. An example of this can be seen in the fact that if a client wants an oxygen plant, although certain Engineer-Constructors may have the engineering and construction expertise in an ethylene complex, it may not have the process knowledge to compete with firms that work primarily in oxygen plants. Couple this with the fact that the clients scrutinize the past record of similar plants in operation built by the Engineer-Constructor, the potential bidders for a particular project are for all practical purposes limited.

Until recently, 1972, the bidding of petrochemical complexes by the large Engineer-Constructors had been primarily on a Lump Sum basis. The reason for the ability of the various clients to obtain a Lump Sum quotation dealt with the fact that the quantity of work available was small in relation to the number of Engineer-Constructors, deliveries of materials along with escalation were predictable, and suppliers had materials stocked in their warehouses, thus they were able to quote to the Engineer-Constructor on a firm prices.

Then in 1973, with the rapid depletion of vendors supplies, rise in inflation, and the increased quantity of projects, the Engineer-Constructor was put into a position where he was not required to bid on a Lump Sum basis. He was able to obtain enough work on a Cost-Plus or Fee type of contract. Couple this with the fact that the size of the complexes were getting astronomical and that in the bidding of these mammoth complexes the Engineer-Constructor, under most conditions, knows only the type of process with the actual engineering and specific construction details not yet developed, the Lump Sum Bid became unobtainable by the clients. Although the basic Flow Diagrams may be known, many months of engineering remain before the Approved for Construction Piping and Instrumentation Diagrams are developed. It is often the case where the location of the complex will not be available from the client, since this would jeopardize the negotiations for the site or negotiations with the local government agencies for tax benefits.

Couple this with the current escalation problems, long duration of the project, and other conditions, the Engineer-Constructor does not have enough information to bid a large complex on a Lump Sum basis. The large Engineer-Constructor use mostly statistical and conceptual estimating in order to establish an estimate cost of a project.

It should be noted at this point that in most cases, the estimate which is put with the proposal is based on company originated data and is not based on quotations received from the potential vendors or subcontractors as is often the case in commercial building work.

The establishment of the method of execution of a project becomes of primary importance to the client. How are you going to engineer and construct the project, when and if we select your firm? How are you going to finish the project on schedule? Do you have the staff to perform the work? These and other similar questions are asked by the perspective clients.

In order to answer these questions the Engineer-Constructor will put together a proposed execution plan for the client's review. A Proposed Master Project Schedule will be developed which will reflect the Engineer-Constructor's best judgement on what construction items will be subcontracted or done on a direct hire basis.

Under most conditions the Engineer-Constructor will submit various methods of project execution, with the related schedule and cost estimates. Usually the methods proposed are (1) totally subcontracted and (2) mixture of subcontracts with most work being done on a direct hire basis. Depending on the client requirements in the invitation to bid the method of construction would be agreed upon between the successful Engineer-Constructor and the client at time of award of the project.

Many times, within the Engineer-Constructor's proposal to the client, a listing of specific items which the Engineer-Constructor feels should be subcontracted are listed. To establish this list in the proposal stage, the Proposal Manager, Construction Division, and the

Supervisor of Subcontracts will review the company's current philosophy and engineering methods, all with regards to the project location and labor area if known. This information will be compiled into the company's proposal and reflected into the Proposed Master Project Schedule. If the contract is awarded to the company the proposed plan will become the basis for the final construction plans which will be developed after contract award.

When the contract is awarded, a firm plan is developed to establish the philosophy which will be taken with regards to the engineering and construction for the duration of the total project. At this point a Project Manager will be assigned who will have the total responsibility for both the engineering and construction of the complex.

One of the first duties of the Project Manager is to establish his overall plan of project execution based on the prime contract with the client. The determination of the feasibility of doing work on a subcontract basis must also be established. The method which is used by one company is to make a detailed listing of all equipment and materials that are anticipated to go into the project. Next, each item is catagorized as to which department or type of subcontractor will buy and erect each item.

This coordination plan is reviewed by the Construction Division, Procurement and Engineering Department, and Supervisor of Subcontracts. Each of the engineering disciplines will review their appropriate portion of the coordination plan. As each group and department reviews the coordination plan the expertise of many disciplines and experience come into play with the overall objective of establishing the most economical project for the client and the Engineer-Constructor within the ground rules established in the prime contract.

The Construction Division will concentrate their analysis of the coordination plan on the labor and manpower availability in the local project area. An indepth study will be made of the availability and quality of labor and doing the work on a direct hire basis versus the use of outside or local subcontractors. A study will be made of the experience of the Engineer-Constructor and other outside companies as to (1) the productivity achieved on a direct hire basis versus using the local subcontractor, and (2) the feasibility of bringing in outside subcontractors to perform portions of the work.

The Construction Division's field staff requirements will be checked as to the availability of staff personnel and other supervisory personnel in order to supervise the project on a direct hire and subcontract basis. The economics of hiring additional people will be studied in order to staff the project adequately. The logistics of having the sufficient number of trained company oriented personnel available to obtain proper efficiency of the labor force if the project is done on a direct hire basis, versus having a smaller number required to monitor the project if it is being done on a subcontract basis, could influence the decision to either do the work on a direct hire or a subcontract basis. If time permitted the training of new personnel to perform certain functions that were traditionally done on a subcontract basis, this may also influence the project decision.

In conjunction with the Construction Division, the company's Labor Relations Department would advise the company as to the potential labor questions which may arise if work is done (1) on a subcontract basis using local versus national outside subcontractors or doing the work on a direct hire basis, and (2) the probable productivity problems which could develop depending on the method of construction used. As required, the Labor Relations Department would attempt to obtain a local agreement with the various trades unions in the area.

The Engineering disciplines will generally concentrate their review of the coordination plan with the objective of establishing the optimum type and quantity of engineering that will be required for the project. The extent of specialized engineering which may be required for which the company may not have trained staff engineers will be studied with the possibility of subcontracting specialized types of design in order to minimize the hiring and training of engineers who will be of value for only one project. This often will come about when there is a specialized piece of equipment which will be required for only one project. If this is to be the case, the decision must be reached as to the extent of design and procurement work that may be required by the subcontractor. The philosophy is generally held that if the specialized engineering and fabrication is given to another firm it is also advisable to have the other firm install the item, thus eleminating much of the interface problems between the fabricator and the erector.

The determination of what is to be subcontracted will directly effect the manner and extent of the company's engineering. If certain items are to be designed by the subcontractor, then the company's engineering drawings will have to define the interfaces of the company's work with that of the subcontractor's.

Both the Engineering and Procurement Departments will closely scrutinize the extent of items which should be purchased by the company and/or the subcontractor. This will directly effect the manpower requirements of each department for writing the engineering requisitions and purchasing of materials. Under most conditions when using a subcontractor the company will purchase the long delivery items and place bulk orders for the major commodities. The balance of the bulk orders will be supplied either by the subcontractor if erection is by the subcontractor, or the Construction Division if the work is on a direct hire basis.

An analysis will be made as to the possibility of the subcontractor being able to purchase items under more favorable terms than the Engineer-Constructor. Often the subcontractor has more influence in purchasing certain items which he buys on a continuing basis throughout the year. He may be able to obtain these items with a better delivery or price than the Engineer-Constructor. An example of this is in the construction of buildings for a petrochemical complex. Although there is usually some type of building associated with the complex, the quantity of say the doors is small. Even multiplied by the many projects which the Engineer-Constructor may do in a single year, the quantity of the doors is insignificant as compared to a general subcontractor who erects buildings all year.

The advantage of accelerating the construction schedule by taking advantage of the items normally stocked by the larger subcontractors in their warehouses is also weighed, along with saving of engineering manhours by the elimination of the company making a material take-off. The subcontractor could thus be given the responsibility for the material take-off and thus minimizing the company's responsibility of a delay in schedule because of late or shortages of materials.

In conjunction with the material purchases, it must be decided what materials will require special material or performance warrantees. It may be advisable to award a subcontract in order to have the subcontractor maintain the total Turnkey responsibility, so if any malfunctions should develop, the Engineer-Constructor can hold the subcontractor liable for either supplying, erection, or performance of the materials. This is often the case in items such as Precipitators or Cooling Towers.

The Project Scheduler reviews the coordination plan for its impact on the overall Master Project Schedule. The lead factors for the establishment of subcontracts and for the required material purchases, whether by the subcontractor or the company, will be checked in order not to extend the project schedule. It may be decided to sacrifice cost in order to obtain the desired delivery which may be required in order to maintain the orderly and overall economical construction schedule. If it is indicated that certain types of work are to be subcontracted their effects on the engineering schedule will also require checking. A determination will also be made to establish the extent of engineering data which will be available to determine if a lump sum, time and material, or unit price type of subcontract inquiry will be issued. The client's requirements may not allow certain types of subcontract pricing and a determination will be required to establish if compliance with the client's requirements are possible. Special approvals may be required in order to permit certain types of subcontract pricing. The Project Scheduler will ensure that the use of the subcontracts does not delay the overall project schedule which was agreed to in the Engineer-Constructor's prime contract.

Within some large Engineer-Constructor companies there is established an independent group for control and evaluation of subcontractors. In one company this group is independent from all other departments including procurement. For the purposes of this study, the head of this subcontract group will be called the Supervisor of Subcontracts. The primary function of the Supervisor of Subcontracts is to ensure that all subcontracts issued by the company are complete, biddable and non-conflicting. The Supervisor of Subcontracts maintains a directory of up to date information on possible subcontractors which may be used by the Engineer-Constructor and he is aware of the problems which the company may have in subcontracting or doing work on a direct hire basis throughout the country. The Supervisor of Subcontracts keeps up to date on subcontract activities throughout the country with regards to the current status of subcontractors and their capabilities, along with the company's current engineering and construction philosophies.

The Supervisor of Subcontracts maintains detailed records on the subcontractors past performance, financial qualifications, geographical preference, labor affiliations and other pertinent information.

When reviewing the coordination plan, the Supervisor of Subcontracts will review the capabilities of both local and national subcontractors capable of performing the work that is anticipated to be done on a subcontract basis. Problem areas will be analyzed with regards to the Engineer-Constructors past history.

Prior to a decision to subcontract work, an evaluation will be made, coordinated by the Supervisor of Subcontracts, as to the practicality and economics of using local versus national subcontractors or doing the work on a direct hire basis. The estimated dollar value, schedule requirements, subcontractor availability, client and engineering requirements, along with construction and labor problems will be incorporated into this evaluation.

The final recommendation within the company as to whether an item of work will be subcontracted or done on a direct hire basis is made by the Project Manager. The Project Manager works closely with the client in order to obtain the client's philosophy on the use and type of subcontracts for the project. At this time the client's preference as to the use of local versus national subcontractors will be established and reviewed.

Since most of the current petrochemical Engineer-Constructor prime contracts are of a reimbursable nature, the client more often than not has a large input into the method of project execution and type of subcontracts and subcontractors to be used. Often the client will require in the prime contract that prior to subcontracting work by the company the client's approval will be obtained along with approval of the bidder's list. Depending on the client's knowledge, this could work to the benefit or detriment of a project.

Due to the large amount of capital required to build a petrochemical complex, the type of firm which the Engineer-Constructor is dealing with is usually a large conglomerate. It would appear at a quick glance that this would mean that the client is well aware of the problems of construction since their organizations are building on an almost continuous basis. In many cases this is true but problems arise when the client attempts to require its construction and subcontract philosophies to be followed indiscriminately. Even though a client is building on a continuing basis, the area of their construction activity is often not in the area where the new complex is to be built. The fact that the construction problems which have arisen on the client's previous project in one area of the country may not be applicable to another area are often very difficult to prove to a client. The problems that the client had on a previous project with another Engineer-Constructor, even in the same area as the new project, are likewise very difficult to convince to the client as not necessarily being the critical factor in the decision as to whether to subcontract or not an item of work. If the client's management had a difficult time or lost money on say an electrical subcontract in one area of the country, they are many times reluctant to agree with the issuance of an electrical subcontract even in another area of the country. Likewise, if they had good results with the present Engineer-Constructor in doing work on a direct hire basis in one area of the country they will be reluctant to do work on a subcontract basis in another part of the country. The company's hands are often tied by the client's wishes and not permitted to follow its normal procedures because "it's the clients money and if he wants to do it, we'll do it." The attempt to please a client and do what he says can often cost the client more money than if he would rely on the Engineer-Constructor's expertise in this manner. The large Engineer-Constructors makes a business of keeping abreast of the labor situation around the country and should advise the client on the best way of executing the work rather than being told how to do the work. With a very knowledgeable client, with knowledgeable management on both sides, the project costs could be kept to a minimum by choosing the proper items to be subcontracted.

Another type of client is the medium size petrochemical client who builds a project every few years, rather than on a continuing basis.

This type of client many times has little awareness of the current market and labor conditions in the industry at the time the project is being built. Previous projects which they have built will be used by the client as a basis for decisions. These projects may have been built 4-5 or more years previous and possibly in another part of the country. The requiring by the client that the Engineer-Constructor follow their philosophy can again become dangerous.

Until the late 1960's, the Engineer-Constructors did most of their construction of petrochemical complexes, except in very select areas, on primarily a direct hire bases, only subcontracting out certain specialized items. The late 1960's saw a rise in labor influence. Coupled with the growth of the large specialized subcontractors, this started the tendency to shun away from labor problems and leave the construction of the complexes to the subcontractor, with the Engineer-Constructor only managing the project.

Because of the above and similar situations, the large Engineer-Constructors began to do an in depth analysis of the local labor conditions prior to deciding on doing the work on a direct hire or subcontract basis.

There are certain types of work which the Engineer-Constructors normally subcontract. These are items of work which require a specialized type of engineering, fabrication and/or erection. This type of work is normally left to the specialty subcontractor unless there are special circumstances dictating otherwise. It has been found that from a total financial viewpoint, it is more economical to subcontract the specialty work items rather than to maintain a staff of specialty engineers and construction personnel on the Engineer-Constructors payroll to design and construct these items. The specialty subcontractor maintains a staff of expert engineers and erectors in order to supply the Engineer-Constructor with the most economical product thus the Engineer-Constructor avoids keeping specialty personnel on their staff. The specialty subcontractors also have the ability of providing the research and design experience which would be very difficult for an Engineer-Constructor to economically maintain.

An example of this is the subcontractor who designs, fabricates and erects Wood Frame Cooling Towers. Although the Engineer-Constructor may keep Project Engineers who are Cooling Tower Specialists, their primary function is to specify the proper design criteria for a Cooling Tower rather than trying to completely design the most economical Cooling Tower. By subcontracting for the design, fabrication and erection of the Cooling Tower the subcontractor must design the most economical tower to be competative. Since the Cooling Tower subcontractor's construction staff erect Cooling Towers all year round their expertise would be hard to capture for an individual within the company who may have the opportunity of erecting only a limited number of Cooling Towers. The general concensus of most Engineering-Constructors is that the productivity achieved by the specialty contractors who do the same type of design and construction work daily, combined with the sole responsibility for design and performance by one subcontractor, more than pays for the profit which is required to be paid to the specialty subcontractor. If the Cooling Tower does not perform as specified, there is little question as to who is responsible and who will repair the Cooling Tower.

Other areas that fall in this catagory are items such as Soil Investigation, Pre-engineered Building Construction, Precipitators, Conveyor Systems and Elevators.

Certain other items where there is an associated material warrantee required are also usually subcontracted by the Engineer-Constructor with little objection from the clients. These are items such as the painting and insulation of a petrochemical complex. The purpose again for subcontracting these items is to maintain the sole responsibility for both supply and application of the material, along with the performance required of the materials. The specialty subcontractor again has more expertise in this field than the prime Engineer-Constructor.

In subcontracting the above items, the problem of vendor print transmittals and delays is also minimized since the Engineer-Constructor does not have to approve vendor drawings. Although the drawings will be checked by the company, the subcontractor can proceed with his detailing and fabrication as soon as the subcontract is awarded.

The ability of taking advantage of the purchasing power of the specialized contractor as described previously also plays an important roll. An example of this is the large Field Erected Tank subcontractor who has a greater influence in the steel industry than the Engineer-

Constructor who decides that it needs steel for only a few tanks a year. The established purchasing power and steel allotments of the Field Erected Tank subcontractor with the major steel industries can often decrease the over all schedule by decreasing the procurement time for materials.

Although the Engineer-Constructor usually has a reimbursable contract with the client, the standard type of subcontract which is issued to the subcontractor is that of a Lump Sum with Unit Prices to cover work that is not known at the time of issuance of the subcontract. This type of subcontract is used if the Scope of Work can be defined to within 70% of what the anticipated value of the subcontract will be. The additional 30% is known conceptually by the Engineer-Constructor but usually will not be definable in a manner that the Subcontractor can bid on a Lump Sum basis without putting in a large contingency factor.

If the Scope of Work can not be defined within 70% accuracy, then an alternate method of pricing will be used. This subcontract will usually then be a Unit Price type of subcontract. The Engineer-Constructor, from his experience, can define the type and approximate quantities which are to be bid on. The estimated quantities are arrived at from past experience and statistical data from previous similar types of plants constructed.

Work which can not be defined in either of the above two methods will be issued on a Time and Material.

The general philosophy for subcontracts is to use either the Lump Sum or the Unit Price version with the Lump Sum being preferable. The purpose for this is that the client's management staff must justify to their supervisors the anticipated total cost of the project. With the use of a Time and Material, Cost Plus Fee, or other similar method, the client will not know the exact cost of the project until the project is complete. With the Lump Sum or Unit Price the client will have a very close approximation of what the project will eventually cost. Although with a very nebulous definition of the Scope of Work many subcontractors have expressed a preference to a fixed fee or sliding fee arrangement, this is usually not acceptable to the client except under very unusual conditions.

An additional reason for the client to require a firm feel for the total value of the project as soon as possible is the fact that the projects normally worked by the company are covering a time period of many years. The client must know the anticipated cost in order to project its cash flow, financial requirements, and anticipated expenditures. The general opinion is that a Lump Sum based on a percentage of the scope of work, or the use of extended unit prices gives a firmer estimate of the final value of the contract than an estimate of the Time and Material costs projected over the next few years.

The alternative, using a guaranteed maximum value for the subcontract, is often unacceptable to the subcontractors since the Scope of Work can not be well defined and the subcontractor's anticipated fee may not relate to the final value of the subcontract.

The decision as to which type of pricing will be used in a subcontract is usually dependent upon the quantity of information which is available during the subcontract Inquiry stages or the type of labor conditions that are prevalent in the area of project. In some areas of the country, due to the unpredictability of the labor market, subcontractors may not accept Lump Sum pricing without putting a large contingency factor. This would then be unacceptable to the client.

Under most conditions the method of pricing will be determined from the Master Project Schedule. If the project schedule requires the issuance of a subcontract inquiry before the work can be defined to the 70% Lump Sum limit, the subcontract will be issued on a Unit Price basis. This fact is known early in the project and is usually accepted by the client.

Revisions to a subcontract are handled in the same manner as the original order, i.e. Lump Sum prices for supplement will be requested on a Lump Sum subcontract and extended Unit Price values will be requested on a Unit Price subcontract.

Under the commercial and legal terms that the Engineer-Constructor uses for subcontracts, the subcontractor is authorized and required to proceed with the work upon receipt of the supplemental data, then advise of the change in price. The purpose for this is that rather than wait for the revised price to be agreed upon by the Engineer-Constructor and the subcontractor, the primary object is to complete the work within schedule. Since the engineering and construction schedules are normally close to being on a critical path the way that a project is bid by the Engineer-Constructor, any delay in construction due to revised drawings could cause a major overall project schedule delay. The revised prices per supplement are closely scrutinized as they are received by the Engineering, Project and Subcontract Groups in the company before approval is made for payment. If a discrepancy is found, the problem is quickly resolved with the subcontractor in order not to hamper the remainder of the project.

In some instances where time permits the subcontractor will be requested to submit a proposal for the revised scope of work and will not be allowed to proceed with the work until the proposal price is agreed upon. The possibility of issuing a separate subcontract for competitive bidding is also reviewed before issuing a large supplement to an existing subcontract.

As can be seen from the above supplement procedures there is a certain reliance on the integrity of the subcontractor.

For this reason and to aid in the issuance of a subcontract the Engineer-Constructor has established the following method for determining the optimum subcontractors. Once it is determined that an item of work will be subcontracted, the objective is to issue the subcontract on schedule, for the least cost, and obtain the optimum bidders for the work.

The method used by the Engineer-Constructor is to establish a list of bidders, with a maximum of 4, who are (1) competitive, (2) qualified, and (3) meet the client's requirements. An evaluation is made of the potential bidders by the Supervisor of Subcontracts based on the companys history of national and local subcontractors and client's recommended subcontractors. The potential bidders are contacted to establish their current interest and anticipated work load. The specific area, approximate value, and scope of work are discussed to establish if it coincides with the current subcontractor's ability and interest. The anticipated list is reviewed by the parties responsible for the company's bid list, i.e., Procurement, Construction, Project Management, Client, and again by the Supervisor of Subcontracts. With the combined experience and further recommendation of the individual parties mentioned, the bid list is established based on the best information available to the Engineer-Constructor at that time.

The purpose for the minimization of the bid list to four (4) is to aid in the expedient evaluation of the bids. By this procedure it is insured that there will be four competitive bids received. The possibility of a no-quote is virtually eliminated by the process discussed above since the subcontractors understand that they will be one of four bidders quoting on the scope of work. If there is a probability that they may not want to quote, the potential bidder will normally tell the Supervisor of Subcontracts in order to be taken off the bid list for the particular project rather than put the company in a position that they receive an insufficient number of quotes and put the

Engineer-Constructor in a bad light.

Since it has previously been established that each subcontractor is financially, experience, and labor wise satisfactory, the only item which has to be established after the bids are received is that of the technical portion of the subcontract, to be sure that it has been interpreted in the manner which the Engineer-Constructor has intended.

Upon review of a preliminary bid tabulation, which is prepared from the quotations received, a preliminary evaluation can be made as to the relative standing of each of the bidders. It has been found by the Engineer-Constructors that since the scope of work is usually only about 70% defined in a Lump Sum inquiry, there is a possibility that the subcontractor has either read too much into the inquiry or has overlooked something in his bid. In order that (1) a contract be written for a value that is acceptable to the subcontractor and Engineer-Constructor, (2) the subcontractor knows exactly what the company is going to expect of him when he starts work in the field, and (3) the subcontractor's bid includes all the work that the company intended to be in the inquiry documents, it has been found that a Pre-Award Meeting is required with the subcontractor in order to review the quotation.

Depending on the exceptions which have been taken by the various bidders, usually at least the low and the second low bidder are called into the Engineer-Constructor's office to determine if the bid submitted contains the required scope which was intended and if there are alterations in the subcontractor's quote required.

The attendees of the meeting will be the Engineer-Constructor's Project Manager, Project Engineering Manager, Project Engineer, Construction Coordinator, and Procurement Subcontract Buyer in conjunction with the Subcontractor's estimator and executives. The meeting will be chaired by the Supervisor of Subcontracts. At this meeting the bid documents will be clarified by the subcontractor as required in order to insure that the quotation submitted match the intent of the Engineer-Constructor. The meeting with the two low bidders will be held separately and revised prices requested in order to insure that the low bidders are bidding "apples to apples." At this meeting there is no intent to negotiate a lower bid but only to resolve scope clarifications. If required, other bidders will be called into the office for clarifications also. Under normal conditions the spread of quotes which are received normally indicates that only two bidders need be invited.

After clarifications are resolved, the bid tabulation is revised to reflect revised prices required during the Pre-Award Meeting. The selection of the subcontractor can now be made with an assurance that the subcontractor understands the complete scope of work which will be required of him and that the price he has submitted covers the work intended.

Although it may appear to be an arbitrary decision as to (1) who the four bidders will be and (2) the selection of usually only two subcontractors of the four being invited into the office for a quotation review, the subcontractors who bid for Engineer-Constructors understand the method which is used. The subcontractors have the knowledge that their estimators have to be accurate the first time in order to be put in a good position to obtain the work. They also understand the critical schedule to which the Engineer-Constructor is working. With the knowledge that they have a one in four chance of getting the work rather than a one in 15 or 20 as often happens in public work projects, their chances of obtaining the project are greatly increased. The subcontractors know of the evaluation procedures which are employed prior to the selection of the four potential bidders and they realize that they will be in competition with other subcontractors of equal caliber. They do not have to worry about an unqualified bidder coming in and underbidding everyone just to take the project and look for money that can be made on extras. They also realize that they have to have their best bid in the first time.

The purpose for this procedure has been to limit, for the company, the time required for evaluation of the quotations and try to insure that whoever gets the subcontract is qualified and has included all the information in his bid that was required. Due to the limited time that the company has to award the subcontract and the knowledge that the scope of work is not always defined to the extend that an Architect can define a building, this procedure has been developed to cover the inadequacies in inquiry documents, clarify these documents to the Engineer-Constructor and subcontractor's satisfaction, and establish a subcontractor as soon as possible and still meet the project schedule.

With the knowledge that the engineering is still being worked on for the project while the subcontract is being awarded, the primary objective is to establish a subcontractor who can do the work that can presently be defined, and have built into the subcontract a method of handling the changes to the subcontract that are sure to come.

The subcontractors that work in the Process Industry are extremely familiar with this method of bidding and understand that there will be more work to come which is not presently defined in their subcontract. The main control in the Process Industry on the subcontractors is the knowledge that the subcontractors are expected to understand the unofficial rules of the game. It must be realized by both subcontractor and company that due to the size of the projects involved both companies must act as professionals.

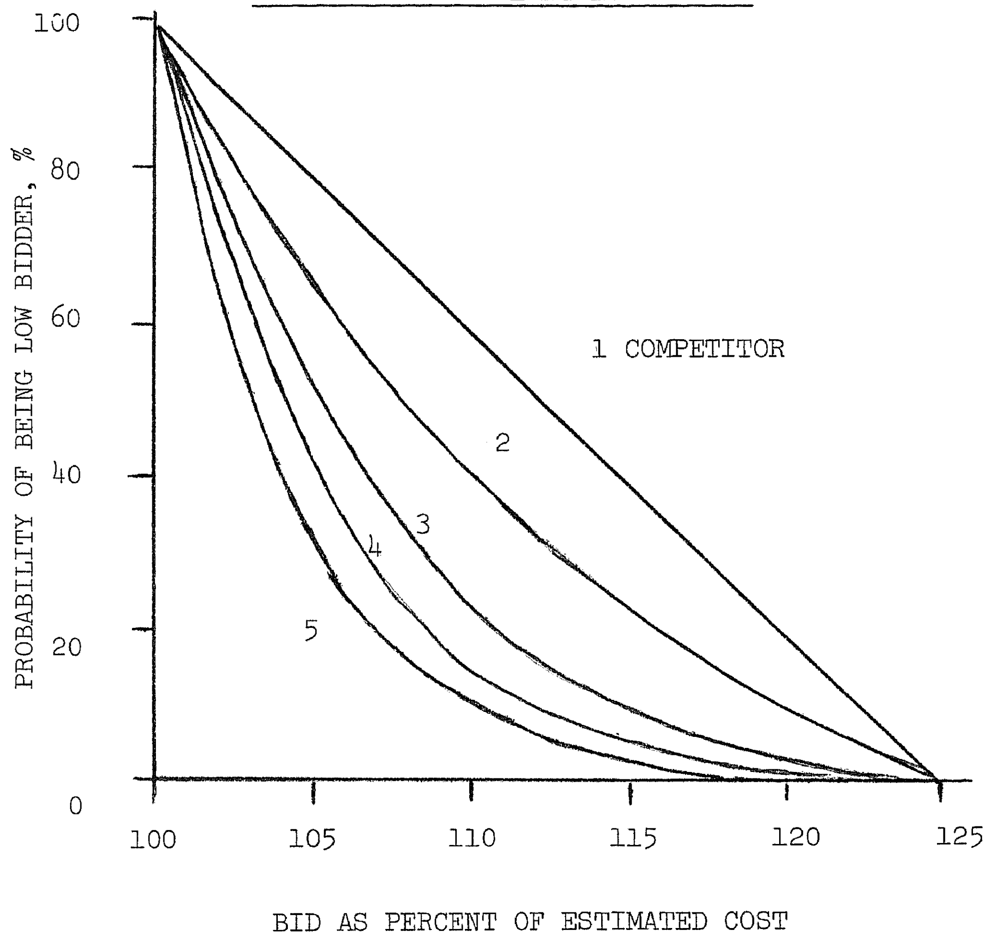
Although profits are expected on both sides of the subcontract, the subcontractor is supposed to be aware of the problems that the Engineer-Constructor has when the work went out for bids in order that it maintain its project schedule. Advantage should not be taken by either party of this situation. Minor problems are to be taken into account in the bidding by the subcontractor. Although this can not be found in writing, it can be seen in most subcontract bid meetings. The only recourse that the company has if the subcontractor takes undue advantage of the situation is to eliminate him from the bid list on future projects. When this is seen by other Engineer-Constructors, there is a possibility that the subcontractor will loose more business than just the Engineer-Constructors business under question. If the conflict becomes too great and arrives at the state of litigation, there is no right party, and both parties reputations are in jeopardy, the subcontractor's for taking advantage of a situation and the Engineer-Constructor's for forcing the subcontractor into a position where he feels that he is loosing money because of a subcontract that was written too strict in favor of the Engineer-Constructor.

The caliber of subcontractors which the company normally works with realize that there is an advantage to being a selected bidder for the Engineer-Constructor, as long as there is no bid shopping done by the company amongst the subcontractors. The subcontractor realizes that their probability of obtaining a project is better with the Engineer-Constructor than elsewhere. The use of the limited bid list enables the subcontractor to increase his probability of obtaining work and thus limiting his overhead costs in general.

It can be seen from the figure chart below[7] how the subcontractor's probability increases with the limiting of the bid list. The main determining factor is the percent above estimated cost the subcontractor desires to put into his bid.

FIGURE 1

PROBABILITY OF BEING LOW BIDDER



[7]J.J. O'Brien and R.C. Zilley, Contractor's Management Handbook, (New York: McGraw-Hill Book Company, 1971), pp. 24-25.

IV. IMPACT OF SUBCONTRACTING ON THE PROJECT SCHEDULE AND COST

Prior to a potential client making a decision to commit large sums of capital into the development of a new complex, a lengthy profit analysis is made by the client as to their overall profit projections. A market analysis is made as to the potential sales value of the finished product, with often tentative agreements being reached for the sales of the products prior to signing a contract with the Engineer-Constructor. It is estimated that for the large complexes this economic evaluation may cost $100,000.[8]

With the market continually in a state of flux, it becomes of extreme importance to have a firm schedule for the completion of the project. If the client receives his plant late, he risks loosing the customers he has tentative agreements with, or at best, loose his optimum share of the market for which the complex is being built.

As often is the case, the petrochemical client will issue invitations to bid on his complex only to a select few Engineer-Constructor companies. This is done after an evaluation of various Engineer-Constructor's past performance with regards to schedule and cost on previous projects, and the client's past record with the individual Engineer-Constructor is checked. Since most projects are presently being awarded on a reimbursable basis, the important items for the client are (1) what is your schedule, and (2) how are you going to

[8] "Boom for Contractors is a Mixed Blessing,: The Oil and Gas Journal, June 3, 1974, p. 93.

meet the schedule. Initial cost at this time is third in importance. Usually in the invitation to bid the client sets the completion date he requires. If the Engineer-Constructor indicates in his proposal that he anticipates completing the project later than that required by the client he can be assured that it is very unlikely that he is awarded the contract. The missing of this completion date can cost the client many thousands of dollars in lost profits.

With the completion date so established by the client, it is the Engineer-Constructor's responsibility to establish the most expeditious and economical method of executing the project.[9] It is important to emphasis at this point, that the overall project cost impact to the client must be analyzed rather than the individual costs of engineering, construction, or procurement. The client's profit picture and financing also enters into the analysis. Even though in some cases it may be more costly to perform a task or purchase an item one way, when the overall cost impact is studied the decision may be made to spend extra money now in order to save later.

For a typical complex, the construction costs as compared to the Total Installed Cost (TIC) are approximately 17%.[10] It can thus be seen that even if a savings of 20% in subcontract costs were realized, with

[9] "The Contractor's Challenge to Rising Costs," Chemical Engineering Progress, Vol. 66, No. 10, p. 23.

[10] C. Freeman, "Chemical Process Plant: Innovation and the World Market," National Institute Economic Review, 1969, pp. 29-58.

subcontracts representing an average of 30% of the construction work, this only represents a savings of 5% of the total cost of the project. Based on an average project of $75,000,000 this represents a savings to the client of $380,000. Although this is a significant figure, for a 900 mill. lb./yr. ethylene plant, using a conservative figure of 2¢ gross profit/lb, this represents a gross profit loss of $1,500,000 per month.[11] This figure is excluding the intangible profits which could be achieved by a client who delivers his product to its markets on time.

As implied above, the schedule that is submitted to the client in the Engineer-Constructor's bid proposal, and which is approved by the client when a contract is awarded, is based on the most optimistic lead factors, with the purchasing being performed as early as possible in order to allow time for construction to complete by the established end date. Bulk orders for commodities are placed by the Engineer-Constructor with little more than an estimate based on a similar plant which the Engineer-Constructor built in the past. The amount of float in the schedule has all but been eliminated by either the client's compressed schedule requirements or the lead factors for material delivery. With the construction schedule established based on the material deliveries and the engineering schedule, the construction mobilization time is then incorporated into the schedule for the

[11] J.T. Gallagher, "A Fresh Look at Engineering Construction Contracts," Chemical Engineering, September 11, 1967, p. 218-224.

subcontracts by backing off from the construction schedule. It can now be seen what percentage of the engineering data is available for the anticipated subcontract by checking the percentage of engineering which will be complete when the subcontract inquiry requisition is to be issued.

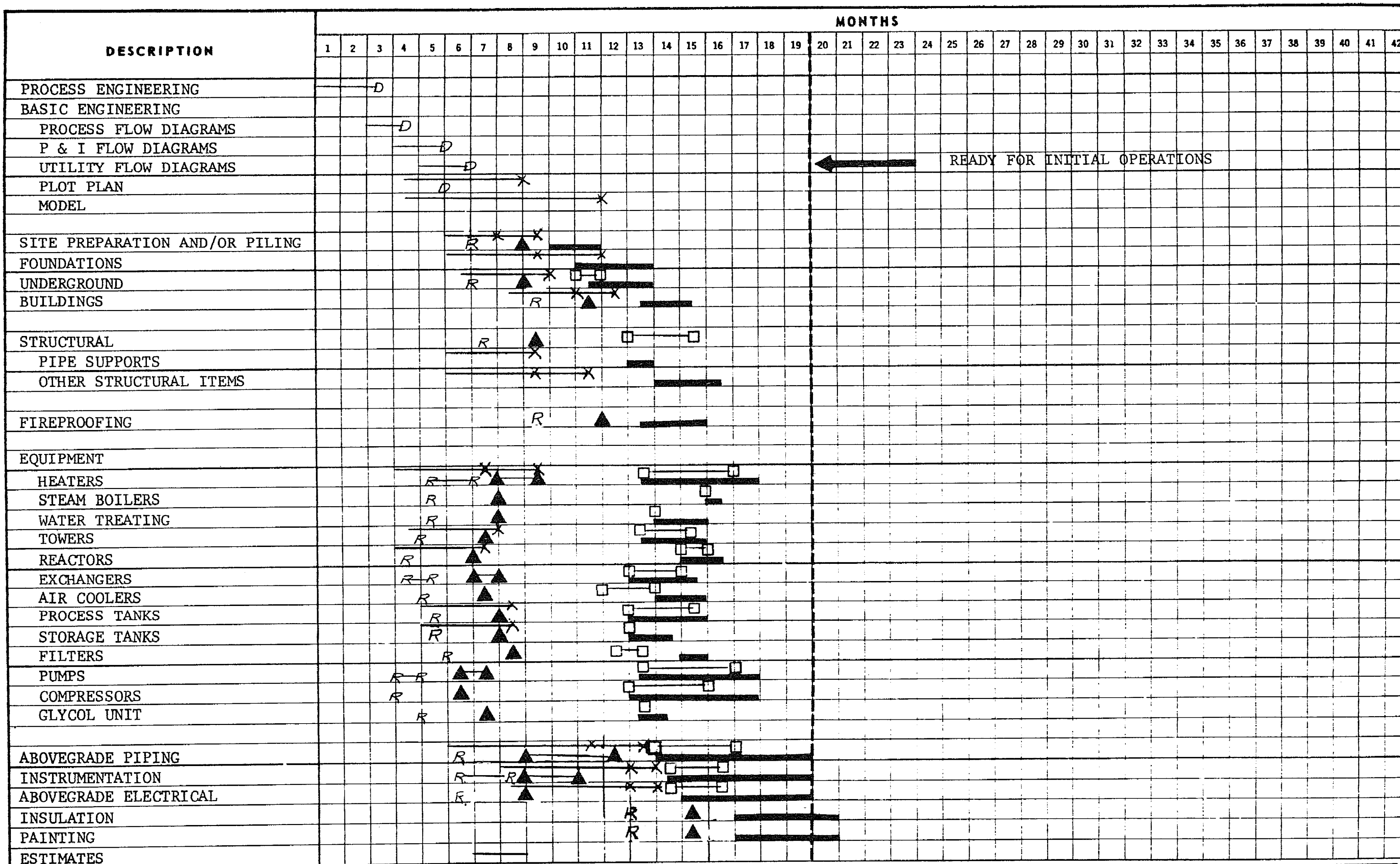
Since there is little float in the schedule, any attempt to accelerate the construction schedule creates a situation in which well under 70% of the engineering data is available, thus forcing the company to issue a subcontract inquiry on other than a Lump Sum basis, which most clients dislike.

If it is decided to wait longer before going out for a subcontract inquiry this could cause a delay in the completion of the project.

In comparison to the issuance of subcontracts which cover major types of work for the complete project, i.e. all foundation work, the other alternate would be to issue a series of subcontracts for each type of work as the work becomes defined by the engineering departments. This allows the subcontract to be more than 70% complete for bidding and meet the client's requests for Lump Sum subcontracts.

Figure 2 below indicates a schedule for a typical 19 month project completed on a Direct Hire basis while Figure 3 represents the same project but scheduled for a total subcontracted method of construction.

The basic engineering design, including the establishment of the Process Flow Diagrams, P & I Flow and Utility Flow Diagrams, takes



LEGEND

— - ENGINEERING/DRAFTING
P - PRELIMINARY ISSUE
R - ISSUE FOR INQUIRY
▲ - PURCHASE ORDER PLACED
△ - ISSUE FOR APPROVAL
□ - SCHEDULED DELIVERY DATE TO JOBSITE
▬ - CONSTRUCTION
Δ - SUBCONTRACT PLACED
X - ISSUE FOR CONSTRUCTION
D - ISSUE FOR DESIGN

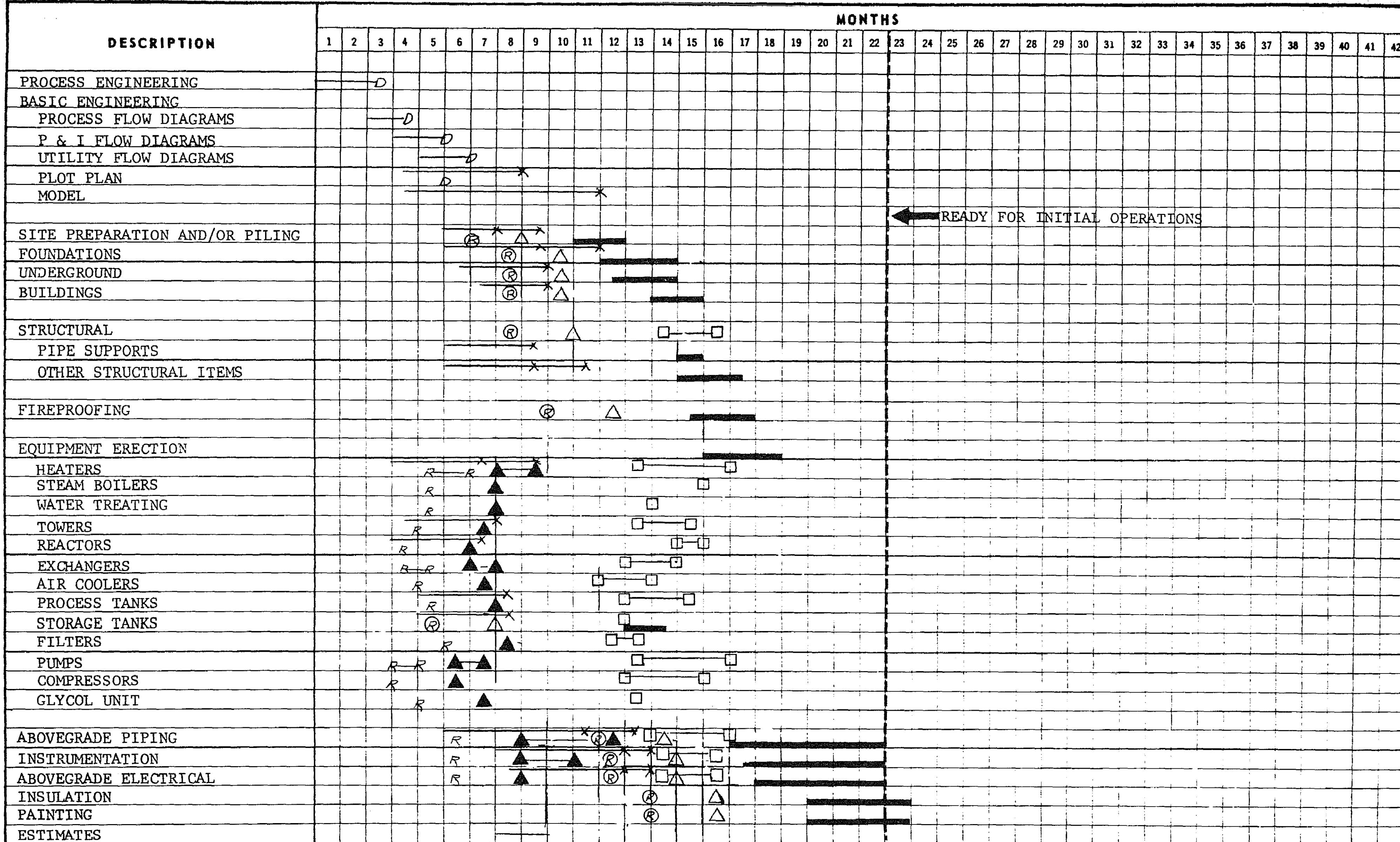
FIGURE 2

JOB NO

DATE

MASTER PROJECT SCHEDULE

TYPICAL SCHEDULE FOR A PROJECT WITH TOTAL DIRECT HIRE CONSTRUCTION



LEGEND

- — - ENGINEERING/DRAFTING
- P - PRELIMINARY ISSUE
- R - ISSUE FOR INQUIRY
- ▲ - PURCHASE ORDER PLACED
- A - ISSUE FOR APPROVAL
- Ⓡ - ISSUE SUBCONTRACT INQUIRY
- □ - SCHEDULED DELIVERY DATE TO JOBSITE
- ▬ - CONSTRUCTION
- △ - SUBCONTRACT PLACED
- X - ISSUE FOR CONSTRUCTION
- D - ISSUE FOR DESIGN

FIGURE 3

JOB NO | DATE

MASTER PROJECT SCHEDULE

TYPICAL SCHEDULE FOR A PROJECT WITH TOTAL SUBCONTRACT CONSTRUCTION approximately 6 months. The engineering of the complex is substantially complete by month 13, thus the bulk of the design engineering is complete within 7 months after design criteria is established.

It can be seen from a comparison of these two schedules that it takes approximately three (3) additional months to complete the project under a totally subcontracted method.

Under the present method of engineering a project, it can be seen that there are only minor effects on the Engineering Schedule when changing from the Direct Hire to Subcontract Method of construction.

In the comparison of the two schedules the primary delays in completion under the subcontract method can be traced back to two primary items, (1) Structural Steel Erection and (2) the Mechanical Work.

In order to obtain enough information for a Lump Sum Subcontract for Structural Steel Erection it requires that the Subcontract Inquiry is issued in month #8. This delay of one month in comparison to the material purchase issue in month #7 in the Direct Hire Method is caused by not only the required additional technical information for a subcontract but additional preparation time required for the subcontract. Compound this by the additional bid time required and the result is a delay in starting structural steel erection of two months.

The Mechanical Subcontract is usually the key subcontract on a project. This subcontractor performs both the Equipment Erection and

Abovegrade Piping. By the use of a Direct Hire Method, equipment erection can commence just after the equipment arrives. Under a Subcontract Method approximately a month mobilization is required. This yields a month delay in equipment erection completion.

Since pipe erection relates directly to the equipment erection, material deliveries, and subcontract lead factors, on a subcontract basis the piping will be delayed until month #17 whereas in the Direct Hire Method it starts in month #14.

With the remaining subcontracts or work following the piping the overall effect is a delay of three months in schedule.

One of the main influencing factors of issuing a subcontract, with regards to the Master Project Schedule, is the lead factor that is required from the time the Supervisor of Subcontracts starts to collect the data required for the subcontract inquiry, to the time that the subcontract purchase order is issued.

Work doing on a subcontract basis the Engineer-Constructor is usually under an obligation to obtain for the client three competitive bids. Unlike the general public work practice, the Engineer-Constructor has the perogative to limit his bid list or go sole source as he sees fit. With the use of a limited bid or sole source bid the Engineer-Constructors have found, based on the current organization for issuance of subcontracts, that the following lead factors are required for award of a subcontract.

TABLE 2

LEAD FACTORS FOR SUBCONTRACT ISSUANCE

	Item	Time Required 3 Bidders - 1 Bidder
1.	Inquiry Requisition Preparation and Issue to Procurement	2 Wks. - 2 Wks.
2.	Incorporate Legal and Purchasing Requirements, Mail and Received by Bidders	2 Wks. - 2 Wks.
3.	Bidding Time, Quotations Received (Average)	4 Wks. - 3 Wks.
4.	Bid Tabulation Made, Preliminary Review	1 Wk. - 1 Wk.
5.	Proposal Review Meetings	2 Wks. - (Incl. in 4)
6.	Clarifications Received from Proposal Meeting	2 Wks. - 2 Wks.
7.	Revised Bid Tabulation, Selection Made, Signed Off By Required Officers	2 Wks. - 1 Wk.
8.	Purchase Order Prepared and Issued	2 Wks. - 2 Wks.
TOTAL TIME REQUIRED		17 Wks. - 13 Wks.
TOTAL TIME EXCLUDING INQUIRY PREPARATION		13 Wks. - 9 Wks.

The above lead factor is required to be added to the material purchase lead factor required by the subcontractor for his purchase of materials. It is not unusual for a subcontract to be placed two years ahead of the actual field construction start date. An example of this is the supply and field erection of a heavy walled steel alloy reactor which can have a material and fabrication lead factor of 24-27 months after placement of the subcontract.

As can be seen from Table 2 there can be a reduction in lead time of approximately a month by using a sole source bid procedure. The added advantage of the sole source bid is that if it is decided early that the sole source procedures will be used, the subcontractor can be brought into the office and a subcontract negotiated prior to having complete drawings which normally are required if a competitive bid is required. The subcontractor is mobilzed and in the field as soon as the Approved for Construction drawings are complete. In doing this however, it must be realized that it is very possible, if the subcontractor is brought in too early, he will not have enough information to bid a Lump Sum price and the Engineer-Constructor could be committed to accepting an alternate method of pricing. In order to maintain the Lump Sum pricing, the main advantage of going sole source is to issue the sole source subcontract inquiry approximately one month later than under normal bidding conditions and thus be able to better define the work scope and include much more than 70% of the total engineering data.

The next question to answer is, "Will the client actually get their complex early by going sole source?"

As described above, in the method that a project is sold to the client by the Engineer-Constructor, the controlling scheduling factor is the engineering schedule and the material delivery rather than the construction phases of the project. The establishment of basic design criteria is the critical item. The method of going sole source for the construction does not appear to give any advantage in decreasing the over all schedule of a project. This is because the basic design information is not available to the subcontractor for a specified time period.

There is another possible complication which could develop when issuing a sole source bid. The negotiating power of the company and the client, in attempting to settle on a subcontract, is extremely hampered. The Engineer-Constructor could be committed to accept certain commercial or engineering alternatives he does not desire, otherwise he must now go out for competitive bids. In doing this, the tight schedule which the Engineer-Constructor has maintained would be completely ruined and the client could possibly not get his plant on time. There is also the possibility that subcontractors who would have bid on the work, if it had been put out for competitive bids, now will not want to bid the project, or else, if they do bid, they may inflate their price with an added contingency factor due to the fact that it has been shown that the company is ready to possibly pay a premium to get back on schedule.

The changing of the method of pricing from Lump Sum to another method will allow the subcontract to be issued at an earlier date. This is normally used if the intent of the subcontract is to have the subcontractor purchase the bulk of materials rather than the Engineer-Constructor. At this extreme, the Engineer-Constructor will have to ensure that he issues the subcontract for inquiry far enough in advance for the subcontractor to purchase and deliver materials to the site in time to meet the overall construction schedule.

The use of direct hire for the work has the advantage of eliminating the subcontract bidding time, thus eliminating the 13 week lead factor detailed above. This will thus allow the Construction Division to start work as soon as the first Approved for Construction drawing is issued. It should be noted here that the determination of whether an item is to be subcontracted or done on direct hire is determined by more than just schedule, but schedule would have a very great influence if the decision does not have other outweighing factors.

If it is determined that an item is to be subcontracted the one area that appears to need improvement by the Engineer-Constructor is in the time it takes the company to award a subcontract. The 17 weeks detailed above for preparation and issuance of a subcontract appears to be excessive.

From the Figures 2 and 3 above, certain items should be looked into by the company in order that the lead time be decreased and allow the subcontract inquiry to be issued at a later date with more complete engineering information. It appears from investigation that the reorganization of the method of incorporation of the legal and commercial portions of the subcontract can be reduced from the existing two week requirement down to less than one-half a week. Allowing another half a week for mailing this saves approximately one week.

This could be accomplished by starting the preparation of the commercial documents for the subcontract requisition prior to the receipt of the actual engineering data from the Supervisor of Subcontracts. The assigning of individuals on a project basis rather than just distributing the work as it arrives in Procurement would aid in the continuity and speed the flow of documents to the potential subcontractors.

With prompt attention to the formulation of a preliminary bid tabulation, the immediate selection of subcontractors could be established as to which subcontractor is to be brought into the office for a proposal review. With close coordination with the subcontractors, the proposal review meetings could be held within two weeks after receipt of the original bids, with replies from the subcontractors being within another week. This saves an additional 2 weeks.

Again with prompt attention given to the altered quotations received from the subcontractors, the final bid tabulation could be revised and approved within one week thus saving another week.

Accumulating this savings in time, a reduction in the lead time by approximately 4 weeks from subcontract preparation to award would be the result. Excluding the inquiry preparation time it would now require 10 weeks when competitive bids are required.

The decision as to when the subcontracts are issued on inquiry is primarily established in the Master Project Schedule, which is approved by both the client and the Engineer-Constructor at the beginning of the project. It is decided at that time if the client will require the Lump Sum method of pricing for the subcontracts or if he will accept alternative methods and thus allow an earlier date of subcontract inquiry issue with the possible advantage of having the subcontractor purchase additional materials, thus cutting the overhead of the Engineer-Constructor. Once this schedule is approved there is only a nominal amount of flexibility which will be allowed in the pricing of the subcontracts. The pricing is directly tied in with the percentage of the engineering which is ready when the subcontract inquiry is prepared.

V. NUMBER OF SUBCONTRACTS TO BE USED ON A PROJECT

As stated previously, due to the scheduling requirements of the project when a subcontract is issued for inquiry, the engineering on the project is not complete. It is therefore extremely important to establish early in the project the philosophy which is to be used for the method of dividing the work to be subcontracted. An orderly sequence of events will then take place in the issuance of the subcontracts, and the overall project proceed smoothly. The overall project economics for the issuing of many small subcontracts with a well defined Scope of Work, versus issuing a minimum number of larger subcontracts with a Scope of Work which is not completely defined and the remaining work being added to the base subcontract at a later time and price settled later must be checked. The possibility also arises as to the feasability of using other than a Lump Sum pricing method for the larger subcontracts which can not be well defined. The use of direct hire forces to perform certain portions of work, subcontracting out portions, or doing all the work on a mixed direct hire and subcontract basis, will also have to be analyzed in order to establish the most economical method of constructing the project.

Regardless of value or method of pricing the subcontract, the average lead factor required for the placement of a subcontract by the Engineer-Constructor is 17 weeks including preparation time. Thus, once it is decided on subcontracting an item of work, the same lead factor for each of the subcontracts are applicable if there are many or few subcontracts.

It should be stated at this time the type of subcontracts which are used for a totally subcontracted petrochemical complex. Under the current Engineer-Constructor policy the following subcontracts are normally used:

1. Soil Investigation
2. Site Clearing, Earthwork, Road Base
3. Foundations, Road Paving, and Yard Paving, possibly including Underground Electrical and Piping if not included the Primary Electrical or Piping Subcontract
4. Fireproofing and Refractory
5. Mechanical Work including erection of all piping and pipefitter erected Equipment and possibly the Underground Piping if not included elsewhere
6. Structural Steel
7. Electrical Work including Underground Electrical if not included elsewhere
8. Heater Erection and erection of other Boilermaker equipment and piping
9. Electrical and Pneumatic Instrumentation
10. Field Erected Tanks if applicable
11. Cooling Tower if applicable
12. Buildings if applicable
13. Insulation
14. Painting

The reasoning behind dividing the work in the above catagories is to have the total coordination of work by labor craft and area of work, by one subcontractor rather than having more than one subcontractor working with similar crafts and types of work. The interface problems between the various similar subcontractors can therefore be minimized. The subcontractor has the total responsibility for all the work of a similar type. Aside from minimizing the interface problems by using a minimum number of subcontractors, the costs of issuance and administration of the subcontracts is decreased. During the construction phases of the project, as the coordination meetings are held with the various subcontractors, it is much easier for the Engineer-Constructor to coordinate 10 or 14 subcontractors rather than two or three times as many. The staff, both home office and field, required for the issuance of the new technical data and drawings as they are developed and required by the subcontractors can be kept to a minimum thus making control of the documentation required easier. By the use of only a small number of subcontractors the home office payroll for administrative and support staff, such as accounting and finance, are also decreased.

An approximate cost for issuance and administration of a subcontract within the home office is 250-400 manhours, plus the cost the administrative and support staff in the field. The limitation of this cost per subcontract is a direct savings to the client since these costs are normally reimbursable under the present types of prime contracts which are worked by the Engineer-Constructor.

The main disadvantage in the issuance of one subcontract for the Scope of Work is that in order to issue the subcontract on a Lump Sum basis, which most clients require, the amount of work that can be accurately defined is approximately 70% of what the estimated value of the subcontract will finally be. Although there are controls by the company on the costs for supplements to the base order, there is always the possibility that unnecessary additional monies are being paid. The integrity of the subcontractor is often relied upon by the Engineer-Constructor for equitable pricing of the supplements.

The main purpose of using the larger number of subcontracts is so the subcontracts issued are more completely defined, thus the bids represent a true picture of the anticipated work. For these types of subcontracts the client knows accurately the projected costs of the work. Since the lead factor for these type of subcontracts are identical to that of the above major subcontracts, the major problem is in the overlapping of the issuance of the second, third, etc. subcontract inquiry while the first subcontract for the work is being awarded. Once a subcontractor has been established for a specific type of work and the subcontractor is in the process of mobilization, it is very difficult to convince other subcontractors in the same field that it is worth their effort to bid on additional work, of the same nature, at the same jobsite. The mobilization costs for the second subcontractor would probably drive him out from bidding since it is assumed by the subcontractors that they would be bidding against at least the established subcontractor at the jobsite thus the Engineer-Constructor is left with only one real bidder. Although it is possible to unseat an existing subcontractor, it is realized by both the existing subcontractor and the company that it is often very unprobable, especially if the project is of such a nature that the Engineer-Constructor will be leaving after the project is completed. The tendency might be for one subcontractor not to infringe upon the "territory" of another on a specific project. This could become extremely prevelant if the major subcontractors were local. A danger could arise with the subsequent addition of many small contracts to one small subcontractor if he exceeds his bonding capability.

The major problems in the issuance of a series of subcontracts related to similar types of work are with the problems of labor relations, interfacing of subcontractors, responsibility for the work, and cost to both the client and the Engineer-Constructor.

When dealing with labor relations and jurisdictional problems, which have become a common day construction problem, it is much easier to maintain compatibility amongst the trades if each of the crafts are working for their respective subcontractor. Thus if there is a problem, the dealing with a minimum number of subcontractors is easier than dealing with a multitude.

With the quantity of work which is being required to be performed on a subcontract basis, and only a certain portion which has been described within each small subcontract for the type of work, there is a probability that as the additional work is designed by the Engineer-Constructor that each subcontractor will vie for the work, each knowing that it is an extra to their subcontract. The interfacing of the various subcontractors could develop into a major administrative problem for the Engineer-Constructor, both in the field and the home office. The increased cost for both field administration, and home office administration and accounting, could cause both a financial burden for the Engineer-Constructor and the client if the Engineer-Constructor's prime contract is a reimbursable nature. The interfacing problems, as to what is in one subcontract and what is in a similar type subcontract with another subcontractor, could be eliminated by giving the similar type of work to only one subcontractor.

One of the primary problems of the large Engineer-Constructor when he is constructing a project is to assign the responsibility for the construction in a manner to assure that if something malfunctions that the proper party is responsible and definable. With a series of subconstractors who have similar work functions it is very difficult to determine the exact extent of liability of each of the subcontractors if there is a malfunction in the complex.

The extreme of using many subcontracts on a project is that of doing the total work on the project on a direct hire basis. Many times, as described previously, these requirements are dictated by either labor, scheduling, economics, specific client or construction conditions.

When the Engineer-Constructor decides to do work on a direct hire basis the company is in competition with the local subcontractors for labor in the hiring halls. It is common knowledge that the men in the local hiring halls appear to have a strong relationship for the contractor who will remain in the area for a long period of time rather than a contractor who leaves the area at the termination of a project.

When an Engineer-Constructor decides to do work on a direct hire basis he must weigh the requirements of establishing a complete field organization to manage a direct hire project rather than an organization for a subcontracted project. This would mean that the company is now required to have a field support staff which would be capable of performing not only the day to day supervision of the individual crafts but also perform the support functions, such as purchasing, warehousing, payroll, and secretarial functions. In order to manage these functions the supervisory staff will have to be altered. Where as with a totally subcontracted project, primarily a planning and quality control staff is required, now a craft supervision staff must be added thus adding from 8-20 people depending on the size of the project.

In order to perform this work, economically, on a direct hire basis the Engineer-Constructor will be required to have on his staff many individuals who are experts in many specialty items such as purchasing for each special discipline. As the Engineer-Constructor's present organization is set up, the purchasing of the main commodities are purchased by the home office with the remainder, including construction and miscellaneous items, supplied by either the field or a subcontractor. The field must now spend much time in the purchasing function which will increase the field staff requirements.

Even though this same function is required of the subcontractor, his purchasing staff is mainly in their main office. This eliminates the requirement on the subcontractor to add field personnel, and allows him to perform the purchasing function by his specialist staff in the home office. The subcontractor can thus perform with one person in the office what may take many individuals in the field.

There then becomes a point when there is an economic balance when it is more profitable to have a mixture of subcontracts and direct hire, depending on the area and type of project to be built. The Engineer-Constructor must take into consideration the quantity of material purchasing which the Engineer-Constructor is staffed for and the responsibility which is most economical to be placed on the subcontractor. When making the decision as to the mixture which is to be used, the company is required to evaluate the labor relations in the area, the types of subcontractors which are available in the area, and client requirements. This mixture of subcontracts and direct hire can be used to advantage when there is a possibility of interface problems between one subcontract and another. The company can perform certain interface work thus not delaying the subcontractors. In this mixture, an evaluation will be made of the local labor availability which may be needed for the project versus the advisability of having a large outside subcontractor bring in his staff and labor force from other projects.

VI. ECONOMICS OF SUBCONTRACTING WORK

The primary purpose of a petrochemical Engineer-Constructor, like all other corporations, is to make a profit. One of the best ways to do this is to provide a more economical turnkey package to clients than your competitors.

When reviewing the project execution plan which is to be put with a proposal to prospective clients, the economics of subcontracting work is reviewed in order to provide to the client the optimum construction package.

It is currently costing the home office approximately 250-400 manhours to issue a subcontract for a specific type of work in comparison to engineering issuing data to the field for direct hire construction. It is thus seen that if there are a large number of subcontracts on a project, the home office costs would start to expand rapidly. This expenditure, likewise, must outweigh benefits of doing the work on a direct hire basis in order to make the subcontract a more economical method of construction.

As the number of subcontracts increases, the capabilities of the field administration staff begin to become strained. Once the number of subcontracts exceeds the capabilities of the field staff, an increase of not only the technically oriented individuals but also the clerical and administrative staff is required, in order to maintain an orderly and timely method of construction. With the issuance of a minimum number

number of subcontracts the field staff can be kept to a minimum.

The Engineer-Constructor's home office costs for subcontract administration will also decrease as the number of subcontracts decrease.

With a minimum number of subcontracts, the Procurement Department follow-up, administration, and final close out of the subcontract upon job completion, will also be minimized.

The field planning and scheduling staff can be reduced in order to provide only the necessary coordination function between the subcontractors to insure that the potential conflicts at interface areas are kept to a minimum. The issuance of a limited number of subcontracts rather than a greater number will eliminate the duplication of costs for field supporting functions such as warehousing, sanitary facilities, field secretarial staff, etc.

Prior to the final approval that is required before a subcontract is placed, a comparison is made between the subcontract bid value and the estimate value it costs to do the work on a direct hire basis. If there is a discrepancy between the two which would indicate that the Engineer-Constructor should do the work on a direct hire basis, the decision to cancel the subcontract inquiry and do the work on a direct hire basis can be made.

The method by which the subcontract is priced will have a direct relationship on the number of staff at the site. If the subcontract is of a Lump Sum pricing method, the number of field staff can be kept to a minimum. All that would be required of the Engineer-Constructor is to insure that the subcontractor is performing in accordance with the drawings and specifications. If the subcontract is a Unit Price or Time and Material type, the field organization will be increased in order to continually monitor either the subcontractor's physical work completed or the manpower chargable to the subcontract. This is a strong point for issuing subcontracts on a Lump Sum basis if possible.

The economical feasibility of using a sole source bidding procedure has been discussed earlier. Since it is the responsibility of the Engineer-Constructor to protect the client against possible financial losses on the project, competitive bids of at least three potential subcontractors is almost always necessary for a client, assuming that there is no unusual type of condition which would dictate that a sole source bid is the only practical and economical way of going. An example of this is for supply and erection of a special type of piece of equipment for which there is only one possible subcontractor.

Since most clients are usually not solely owned by an individual, but by stock holders, when audit time comes the Engineer-Constructor will have to justify why a sole source decision was made. These individuals may never have worked or been associated with the project. Even though it may have been decided to go sole source for a good reason, when auditors look back over a 2-3 year period, they may not have the same reasoning, and an atmosphere of question could arise.

There are often requirements which a client will impose on the Engineer-Constructor for subcontracts. Even though it may appear, from a first glance, that it is uneconomical from the Engineer-Constructor's view to subcontract a specific type of work, the client may have reasons which, from his overall corporation view point, may make the subcontracting economical. The client may require the use of certain subcontractors, whether local or national, for various reasons in order to attempt to establish good community and labor relations. He may hope to use the present construction phase as a promotional and educational training period for the local subcontractors and the labor force with the hope of using the subcontractor for the general plant maintenance after the construction phase is over. The client may also try to build up his community relations, by using local subcontractors, to show that he is interested in building up the economy of the area and thus get community spirit behind the construction of a large complex in the area.

It is estimated by the Engineer-Constructor that approximately 20% of the subcontractors who are on the original construction project will eventually aid the client in his maintenance program after construction is complete. This is especially true as the size of the complex gets smaller. With the extremely large plant complexes, the maintenance is accomplished with a special maintenance subcontract issued by the client or the work will be the client's own forces.

This philosophy, although it may appear to be the best for the client, should be under close scrutiny by the Engineer-Constructor before agreeing to either the use a specific subcontractor or to do work on a subcontract basis which the Engineer-Constructor feels could be done more economically on a direct hire basis.

Although it may be advantageous to use a local subcontractor because of his later value to a client, the subcontractor should be closely scrutinized if this is the only reason to either have the work done on a subcontract basis or to put him on the subcontract bid list. The value of the anticipated subcontract should be compared to the normal work load of the potential subcontractor. If the projected subcontract is too large for the subcontractor, there is a possibility that the subcontractor may develop a cash flow problem as the project continues over the ensuing 2-3 years. Just the holding of a 10% retention for the duration of the project could give a small or medium size subcontractor problems, if the subcontract is too large for the subcontractor's present organization. The subcontractors who normally perform work to the $100,000 contract limit would be hard pressed to maintain their organization and cash flow on a subcontract that is in the $2-3 million range. Great care must also be taken in the use of the smaller local subcontractors with the idea of the client using the subcontractor at a later date for maintenance.

The usage of national subcontractors who have the capabilities of working and drawing labor from many areas of the country, along with their accepting large portions of the construction effort, thus decreasing the potential construction cost exposure of the Engineer-Constructor, should be analyzed and compared with the use of the local subcontractors.

When developing the subcontract or direct hire construction project execution plan, it is always kept in mind that the complex must be completed on schedule, otherwise there is a possible loss in profits to the client.

The establishment of the exact cost of the plant at all times is extremely important to the client since the financing of the project is often tied in with other corporate programs. The cash flow of the client can become as critical as that of the small subcontractor described above who has over extended himself. A project is often financed in phases and in order to establish the exact amount of money required for the project the value of the subcontracts can be used to pin point the projected funds required for the next phase. The value of subcontracts are a hard and fast number which a client would rather use than an estimate developed by the Engineer-Constructor.

VII. CONCLUSIONS AND RECOMMENDATIONS

The impact of the decision by the large Engineer-Constructor to subcontract or not to subcontract portions of a petrochemical complex have wide spread ramifications to not only the Engineer-Constructor and the client but also to the economics of the area in which the complex is built. Many inputs are necessary before this decision is established. Items such as local labor relations, quantity of local labor forces, availability of subcontractors, client requirements, value of the potential subcontracts, engineering and construction schedule requirements, and the Engineer-Constructor's staffing requirements for both engineering and construction. If an item of work is to be subcontracted rather than being done on a direct hire basis, the sequence and quantity of subcontracts will have to be established. By use of the proper balance of subcontracts and direct hire the most economical project can be built for the client in the required time frame.

The decision to subcontract work or do the work on a direct hire basis must be made on an individual project basis depending on the interrelation of the many factors stated above. It does not appear that the flat decision should be made by the Engineer-Constructor to do all its construction work by one method or the other until all the facts are accumulated. The present policy of the Engineer-Constructor to review the decision with the various disciplines within the Engineer-Constructor's organization appears to take advantage of the best knowledge available at the time, and still meet the client's requirements.

Although most of the current Engineer-Constructor prime contracts are of a reimbursable type, it appears that the Engineer-Constructor should take more of the lead in the decision as to how the execution of a project is to be performed. The Engineer-Constructor who has national labor agreements should use its national association in developing better long term relationships with the various labor areas of the country, in contrast to the Engineer-Constructor always being an outsider when he moves into a project area. He could thus be able to better compete with the local subcontractors for an equally productive labor force. In doing so, the question of whether to subcontract an item or not will not have to be influenced greatly by the local labor conditions. If the large national subcontractors can obtain and maintain a constant labor force within a specific area the large Engineer-Constructor should develop these same capabilities. In doing this, the Engineer-Constructor would be serving the interests of his client by aiding in the training of the local labor force and making the crafts familiar with the plant. The client will then be able to use the labor force at a later date for general maintenance or hire the individual craftsmen on a permanent basis after the construction is complete if it is the clients desire to establish its own maintenance forces.

Whether to use or not use national or local subcontractors, will become a matter of economics as to the size of the anticipated work. If it is decided to subcontract the work, the availability of qualified subcontractors in the local area must be checked. The advantage of the large national Engineer-Constructor using the same subcontractors for work of a similar nature around the country has advantages in the fact that the subcontractor will become familiar with the Engineer-Constructor's philosophy in handling subcontracts and be familiar with the procedures used by the Engineer-Constructor. This minimizes the breaking in period for a new subcontractor. With subcontractors that the Engineer-Constructor has previously used, it may enable the project to start more efficiently.

The decision to subcontract work then becomes an economic and scheduling decision as to the availability of the Engineer-Constructor's staff, how many different types of permanent employees can be maintained and moved from one project to another, and if the engineering data is available for the subcontract inquiry.

A comparison of the cost to maintain the company's craft supervisors for the duration of the project versus the local subcontractor overhead and profit should be performed by the Engineer-Constructor. This study will determine if it is economical to send the Engineer-Constructor's additional supervisory forces to the project.

Based on the method the Engineer-Constructor uses to schedule a petrochemical complex and the close coordination of the engineering with the construction phases of the project, it appears safe to say that the best method to subcontract work is with subcontracts of as large a scope of work as possible. The use of many small subcontracts, even though the costs are well defined, in comparison to the larger subcontract with only 70% of the work defined, provides little advantage if any. The smaller subcontracts require not only greater overhead cost because of the sheer volume of paper work generated, but also create a greater coordination problem, thus adding additional field and home office staff requirements.

Based on the current engineering and construction requirements, it appears that the current company philosophy of taking advantage of the specialty subcontractor for certain design, fabrication and erection is more economical than the hiring of the many specialized types of engineers, detailers, and erection supervisors. This allows the Engineer-Constructor to transfer to one individual subcontractor the responsibility for the complete performance of an individual work item and allow the Engineer-Constructor to have his Engineers work on phases of the project at which they are more adept.

The mixture of subcontracts, both large and small, becomes an individual problem for each project and must be analyzed on this basis. The scheduling requirements which have been established when the Master Project Schedule is approved, will have the primary influence on the size and mixture of subcontracts. The combination of the scheduling requirements with the client requirements must be reviewed in order to establish the best economic mix for all.

The procedures which the Engineer-Constructor has established in order to issue subcontracts and establish decisions as to the type and quantity of subcontracts appears to have many merits. Retraining of the office staff to complete paper work in a more expedient manner needs some revision. This would allow the scheduling of a project to be compressed in order to have the subcontracts contain more information and limit the amount of additions to a subcontract at a later date. It is possible to issue a subcontract in one month less time than is currently being done by only minor changes in procedures. In doing this, the additional paper work that is required to add information into the subcontract which should have been incorporated in the first place will be eliminated.

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