INTERN EXPERIENCE AT

EXXON RESEARCH AND ENGINEERING COMPANY

AN INTERNSHIP REPORT

BY

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Submitted to the College of Engineering

of Texas A&M University

in partial fulfillment of the requirements for the degree of

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ABSTRACT

Internship Experience at Exxon Research and Engineering Company

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From September, 1981 through May, 1982, the author has served a professional internship with Exxon Research and Engineering Company, 60 Columbia Turnpike, Florham Park, New Jersey 07932.

Working as an engineer, the author has been involved in a variety of undertakings in the area of project management. These undertakings and the author's involvement have been described in this report. Major activities have included development of case study type problems for use in conjunction with a redeveloped Project Management Seminar; development of the rudiments of a field based control system for major capital construction projects; and participation in and enhancement of vendor qualification procedures, shop inspections, and preinspection meetings.

The author feels that he has benefited greatly from the internship experience and hopes that Exxon Research and Engineering Company has benefited similarly.

DEDICATION

To the employees of the

Quality Control Division

of

Exxon Research and Engineering Company

Project Management (Support) Department

ACKNOWLEDGEMENTS

Many people have been of assistance to the author, both during his academic pursuits and his professional internship. It is impossible to list everyone here; however, because of the importance of their contributions, the author wishes to express his thanks and appreciation to some very special people.

Mr. D. E. Smith, P.E., with an open mind, received the internship concept presented by the author and proceeded to improve and implement it. His support and interest throughout the internship has been unwavering. Mr. Smith, in the author's mind, is unsurpassed as an internship supervisor.

Mr. W. E. Wilkins, P.E., has made the months at Exxon Research and Engineering Company the most intensive learning period the author has ever experienced. His knowledge and expertise as an engineer provided an unlimited supply of information. The author feels most fortunate to have worked so closely with an engineer possessing the degree of skill Mr. Wilkins obviously does.

Dr. Charles H. Samson, P.E. and Dr. T. J. Hirsch, P.E., who as co-chairmen of the author's advisory committee, have weathered the storm of paperwork associated with their positions. They both have provided a sounding board for the various ideas and concepts the author has expounded over the period he has spent working on the Doctor of Engineering Degree. Their assistance and guidance has been invaluable. The author feels privileged to have worked with both Dr. Samson and Dr. Hirsch.

Dr. Robert D. Turpin's, P.E. willingness to gamble on someone he did not know, provided a teaching assistantship for the author, thus enabling him to meet his living expenses while at Texas A&M University. His assistance as the Graduate Student Advisor in the Civil Engineering Department has made the road through graduate school very smooth. The time spent working for Dr. Turpin will always be remembered as one of the best.

Dr. W. B. Ledbetter, P.E., while not on the author's advisory committee, took an interest in locating an internship position for the author. Partially due to Dr. Ledbetter's efforts, Exxon Research and Engineering Company and the author were able to get together on an internship position.

Dr. Don T. Phillips, P.E.; Dr. G. R. Johnson; and John L. Sandstedt graciously served on the author's advisory committee. The author appreciated their efforts on his behalf.

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OBJECTIVES

As partial fulfillment of the requirements for the Doctor of Engineering Degree at Texas A&M University, a professional internship with an industrial or governmental organization must be served. The purpose of the internship, as stated by the university, is twofold. First, it should enable the student to apply his/her knowledge and training to the solution of a specific, practical, or relevant problem of particular interest to the organization with which he/she is working. This should be done under the supervision of a practicing engineer who will both direct and evaluate the intern's performance. Second, the internship should enable the student to become aware of the organizational approach to problems in addition to those of traditional design or analysis. Examples cited by the university include problems of management, economics, labor relations, public relations, environmental protection, and legislation; however, the internship need not be limited to these areas. It is pointed out that the student should deal with problems which affect more than one part of the organization in order to give the student the broad-based exposure the program is designed to provide.

Based on these criteria, an internship program consisting of three "modules" has been developed by the author and Exxon Research and Engineering Company. It is one which has given the author a broad exposure to the work of Exxon Engineering Project Management (EEPM), both in the home office in Florham Park, NJ and at field construction sites. At the same time, it has allowed the author the opportunity to focus on specific problems of interest to EEPM and to contribute significantly to their resolution.

THE INTERNSHIP ORGANIZATION

With the title of Engineer, the author has served his internship at the Florham Park, NJ headquarters of Exxon Research and Engineering Company (ER&E), specifically with the Quality Control Division of the Exxon Engineering Project Management (Support) Department.

ER&E is a separately incorporated subsidiary of Exxon Corporation. (See Figure 1) It has its own Board of Directors, made up of two Exxon Corporation officers, three ER&E officers, and five representatives from other Exxon subsidiaries. This Board provides a corporate wide perspective for overview and stewardship of ER&E's activities. ER&E's top management includes a President, two Executive Vice Presidents, and Vice Presidents in four functional areas of science and technology, supported by legal, technical, and other services.

The primary responsibilities of ER&E are: (1) to develop a broad scientific and technological base in order to meet the present and future needs of Exxon Corporation in ER&E's areas of responsibility, (2) to develop technology for converting fuel sources to energy supplies, and (3) to provide engineering services for affiliates - activities in which business plans are translated into investments in multimillion-dollar facilities.

As mentioned, ER&E's activities are carried out in four functional areas:

1. Corporate Research, which is responsible for pioneering research for all of Exxon Corporation's affiliates;
2. Synthetic Fuels Research, which is responsible for formulating, conducting, and evaluating laboratory and engineering programs aimed at developing new and improved technology for the manufacture of synthetic fuels and gaseous fuels;
3. Petroleum Research, which is responsible for the exploratory and applied R&D related to petroleum processes and products, including processes for heavy crudes and for upgrading synthetic feedstocks;
4. Exxon Engineering, which is responsible for providing capital project engineering services to Exxon's affiliates internationally. Its activities include the planning, basic design, startup, and management of projects. It also provides technical services in specialized areas of process and engineering technology, and it manages and supports several engineering R&D programs.

In addition, ER&E has a relatively large service area, which includes the law department, technology sales and licensing, computer technology services, information services, and numerous other technical and corporate services.

Exxon Engineering, the largest of ER&E's four technological areas, interfaces with many activities of Exxon's affiliates. EE's major efforts, involving about 55% of the work force, are concerned with providing technical services for capital projects, to meet the business objectives of Exxon Corporation and its affiliates. This work encompasses planning, process design, project management (direct management of a project execution is usually the responsibility of an engineering contractor), and plant startup (advisory assistance to the affiliate involved). Research and development activities, another 24% of the work, provide a resource base of new technology in diverse areas such as process-control systems, materials, and equipment technology. Technical services, such as troubleshooting, provision of operating guidelines, and technical consulting, amount to 16% of the work, and toolmaking and training activities, 5%, round out the scope of the workload.

Organizationally, Exxon Engineering has four functional departments and a European office. (See Figure 2.) Each of these units participates in carrying out work in all phases of the activities described. These EE functional departments are:

1. Petroleum, which is concerned with project planning, process selection and design, R&D support, and technical service work;
2. Synthetic Fuels, which provides planning studies, process engineering (project design is carried out in the Petroleum Department), R&D support, and technical service work;
3. Project Management, which is involved with contract development and contractor selection, cost and schedule engineering, quality and project systems, and management of the execution phase of capital projects;
4. Engineering Technology, which provides capital project consulting and technical service and conducts EE's engineering R&D programs.

Esso Engineering (Europe) Ltd., a satellite office in London, serves European affiliates through its staff of key people who jointly have expertise in all of the aforementioned areas and who provide in Europe most of the engineering services that have been discussed.

The Project Management Department (EEPM) is the departmental home of the author's internship. The basic objective of EEPM is to ensure that design specifications are transformed into operable plants and that this transformation is accomplished on schedule, within the budget, safely, and with the degree of quality demanded.

EEPM works for Exxon affiliates throughout the world; therefore, it must have or attain up-to-date knowledge on matters affecting plant design and construction on a world-wide basis. This includes knowledge of contractors, manufacturers and labor markets, current cost levels and trends, and contracting terms and arrangements for each country where plants are engineered and built. To accomplish this, EEPM is divided into two functional departments, PM Execution and PM Support. (See Figure 2.) The Execution Department has basically two technical areas: the Project Management Teams, responsible for the actual execution of capital projects, and their home office Project Coordinator backup. The Support department is divided into three technical areas: Cost and Schedule Engineering, Contracts Engineering, and Quality Control Engineering. The Support Department is responsible for ensuring that EEPM is up to date on the many factors that influence the construction industry.

The Cost and Schedule Engineering Division provides cost estimates and schedules ranging from rough Class V through Class IV screening, Class III design basis, to detailed Class II estimates based on final design specifications. These estimates are used principally for evaluating potential manufacturing projects, refinery planning studies, evaluation of design alternatives, affiliate appropriation requests, project management cost control and cost reporting, and for target price purposes on certain types of incentive contracts. Estimates are also prepared in connection with the development of new or improved processes for R&D guidance purposes. Monitoring the cost environment worldwide is another important function of CSED.

The Contracts Engineering Division provides services to affiliates that lead to the awarding of construction contracts, worldwide. Contracts engineers may be involved in contracting for projects or in developing contracting technology. Contracts Engineers in project contracting:

- Develop the contracting plan for the project by evaluating the contract market, location factors, contractor capabilities, and other relevant factors;
- Select the type of contract and contractors for bidding;
- Develop project executive, business, and contract terms;
- Evaluate bids and recommend contractor for award;
- Assist in negotiations, in contract award, and in finalizing the contract;
- Design and implement incentive plans;
- Consult with project managers and affiliates on administration problems;
- Evaluate and record contractors' capabilities;
- Monitor the status of the contract market and its effect on contracting; and
- Improve contracting documents and procedures.

The Quality Control Division, as previously mentioned, has been the divisional home of the author's internship. The division is managed by Mr. D. E. Smith, the author's internship supervisor. Organizationally, the division is sub-divided into five sections: Project Services, Quality Control Systems, Inspection, Inspection Systems, and Employee and Construction Site Safety. (See Figure 3.)

Project Services Section has been the location of the first module of the author's internship. This section's diverse activities and responsibilities, carried out by a group of highly experienced, senior engineers, include:

- Active project management support
  - Consulting
  - Participation on project management teams, including schedule and project execution plan review
  - Manuals maintenance, i.e., Field Engineering Manual, Project Engineer's Manual, Project Manager's Manual
  - Project visits
- Experience/information network
  - Data banks, i.e., contractor personnel files, project record book, etc.
  - Feedback
- Project management training
  - In-house
  - Site visits

- Special assignments
- PM Seminars
- PM TrainEE Program, both in USA and Europe

• Recruiting

The second module of the internship has been housed in the Quality Control Systems Section. This section's main activities include:

• Conducting and coordinating system studies recommended by the 1977 Materials Quality Control Study that created this section and the Quality Control Division;
• Monitor and appraise quality control systems and recommend changes;
• Develop, implement, and manage quality control systems
  - Material Quality Information System (MQIS)
  - Field Quality Information System (FQIS)
  - Manpower Planning Program
  - Responsibility Flow Diagrams
• Implement and operate EEPM Interactive Computing Facility.

The third module of the internship has been housed in a combination of both the Inspection Section and the Inspection Systems Section. The Inspection Section is responsible for:

- Source inspection in vendor's shops
  - By Exxon Engineering inspectors
  - By agency staffs through selection and supervision
  - By evaluating and monitoring contractor's inspectors
- Affiliate support
  - During turnarounds
  - During field fabrication
  - With inspection coordination

The Inspection Systems Section supports the Inspection Section and is responsible for:

- Inspection technology
  - Inspection manual and standards upkeep
  - Quality control engineering
  - Training
- Vendor Data Center
  - Capability
  - Capacity
  - Performance evaluation records
- Business systems
  - Accounting for inspection worldwide
  - Agency agreement development and maintenance
- Coordination and Stewardship of inspection toolmaking activities

The Construction Site Safety Section of the Quality Control Division had not been originally scheduled to be included in the internship; however, as matters progressed, participation in a safety audit was arranged. The responsibilities of this section include:

- Safety program development
- Employee indoctrination
- Pre-construction safety plan reviews
- Site safety reviews/audits
- Safety manuals, statistics, and costs

During the period from September, 1981 through May, 1982, the author has been involved in the sections of the Quality Control Divisions as indicated. The specific activities engaged in by the author have been detailed in the remainder of this report.

EXXON PROJECT MANAGEMENT PRACTICES

INTRODUCTION

Exxon Engineering Project Management Department serves as the primary project management resource for Exxon Corporation worldwide. As part of that role, EEPM provides project management training for engineers of many Exxon operating affiliates as well as for those within Exxon Research and Engineering Company. Recently, this training has even been extended to non-affiliated third parties, including some national oil interests. For many of these engineers, this will be the only formal training in project management they will receive.

As a response to this need, in 1969 an intensive, one-week course was developed to cover Exxon's project management concepts, basic practices, and specific procedures. Since then, this course has been presented successfully over eighty times to more than fifteen hundred people and has helped meet Exxon's growing need for project management skills.

As mentioned, this course, called the Project Management Seminar, is used to acquaint project personnel with the manner in which Exxon Engineering appraises and monitors contractors' efforts during the execution phase of capital projects. It applies more than thirty-five years of experience in the area of project management, representing about 150 projects worth well over $20 billion. Organized in three phases, the Seminar includes:

- Project Management Basics
- Project Engineer's Activities
- Field Engineer's Activities

Although the basis of the Seminar stems from Exxon Engineering's experience with large multi-million dollar projects, the basic principles are applicable to smaller projects. The principles also apply to projects other than petroleum refining and chemical processing plants. The bulk of the Seminar is aimed at reimbursable cost contracts; however, it points out how lump sum contracts differ from reimbursable cost type contracts during execution. It also points out that the size, value, or type of project bears little relation to problems that arise on a poorly planned, controlled, and executed project.

Specific topics covered during the Seminar include: planning, scheduling, cost estimating and control, contracting and subcontracting, job specifications, and appraisal of a contractor's efforts in the areas of cost, quality, schedule, and safety.

To provide a more complete concept of the Seminar's content, a condensed course outline is listed below.

Project Management Basics and Concepts

- Definitions of the various staff functions
- Organization of PM staff to fit the project
- Contractor's staff and project organization
- Outside project support sources
- Participation by affiliates and other organizations
- The project's job specification
- Contracting forms, procedures, and administrations
- Cost estimates and control procedures
- Types of schedules, schedule techniques, and control
- Communication and reporting

Project Engineer Activities

- Basic functions and responsibilities
- Preparation for the job at hand
- Appraisal of the contractor's project planning, organization, procedures, and operations
- Techniques for monitoring contractor's execution of different project engineering activities
- Phasing out and clean-up of the contractor's detailed engineered and procurement activities

Field Engineer Activities

- Basic functions and responsibilities
- Preparation for the monitoring of a contractor's construction work
- Review of contractor's construction planning, scheduling, procedures, subcontracting, labor and material control
- Establishment of construction records
- Definition of mechanical completion and turnover of completed work
- Phase out and clean up of construction activities

The Seminar, being planned around a free exchange of ideas, experiences, and problems encountered, is not intended to be a formal lecture series. If more emphasis on a specific area is desired, the Seminar, being flexible in format, can expand or contract in areas to suit the group.

Over the last several years, accelerating demand for the Seminar has begun to exceed the ability of EEPM to provide the human resources needed to meet the demand. Also, the evolution of the content has extended the focus of the Seminar beyond its original descriptive nature to one that includes more formal training in problem-solving.

As a result of these changes, a major redevelopment of the Seminar has been planned. Dr. George Berke, an education consultant, has been retained to aid in restructuring the Seminar to include a major problem-solving component, to develop an instructor's guide, to revise the course text, and to develop other instructional aids. This will permit the teaching of the Seminar by a wider population of Exxon personnel.

Dr. Berke's work in developing an instructor's guide, course text, and other instructional aids has been directed and supervised by W. E. Wilkins with the actual development of course materials beginning in September, 1981. The author's involvement in this redevelopment has been to develop case study problems based on the actual project experience of many highly experienced senior EEPM personnel.

CASE STUDY PROBLEM DEVELOPMENT

Previously, the Seminar's focus has been directed toward project management concepts and the particulars of Exxon managed projects. Although this approach has been successful, it is felt that by means of case study type problems, the methods in which Exxon actually monitors and appraises a Contractor's efforts on capital projects can be more clearly illustrated.

The first step in the case study development process has involved soliciting ideas from various people in EEPM, the information requested being a general problem concept and a particular area of project management in which the problem concept can be directed. Upon receiving the problem concepts, the author, with the assistance of Bill Wilkins, has categorized them as potential individual problems or group problems. This categorization identifies those problem ideas that, once structured, can be solved by an individual in approximately thirty minutes during the daytime portion of the Seminar. Similarly, it also identifies those ideas that, once put into a suitable problem format, will require approximately two hours for a group of five individuals to solve. An expanded version of the Seminar that will include evening problem solving workshops will be necessary for the use of the rather extensive group problems.

Deeming a problem idea applicable to illustrate a particular point of interest in the Seminar, the author has returned to the originator and gathered additional details to structure the problem idea as a learning aid. This gathering process has included personal interviews, directed reading of project documents, and where necessary, fabrication of details.

In order to illustrate the process of gathering raw data and structuring those data into a problem suitable for the Seminar, a detailed look at the process for two problems, one group and one individual, follows. The particular group problem to be examined is one concerning the effect design changes have on projects and what procedures Exxon Engineering uses to facilitate their handling. (Attachment No. 1) The individual problem chosen as an example deals with appraisal of a Contractor's piping layout for economy and sharpness of design. (Attachment No. 2)

Change Problem

Aside from appraising the contractor's performance, the major function of contract administration by EEPM is the exercise of the project execution controls contained in the contract. Of these, perhaps the most difficult area is the identification and control of changes in the work. Experience shows that design changes are a fact of life on virtually every project; therefore, each project team member should be cognizant of the ramifications design changes have on the projects.

Changes can have a significant effect upon overall project costs. If carried to excess, they dilute and nullify the effectiveness of the control estimate. Additionally, changes also dampen cost consciousness, slow job momentum, and divert attention from more critical areas. With this in mind, a problem has been structured that not only exposes the Seminar attendees to the mechanisms for handling the administration of necessary design changes but also presents the attendee the opportunity to judge the legitimacy of a change request.

To present this topic in the most realistic fashion possible, the following procedure is used:

First, all applicable articles/sections of the Principal Contract Documents and Coordination Procedures are presented as reference material. The articles/sections of these documents are the basis for decisions concerning the legitimacy of a change request, the documentation of the change process, and the necessary requirements that must be present before a change order is permitted.

Next, ten letters addressed to a fictitious Project Manager (the group fills the PM role) requesting changes are presented to each group. The letters originate from a variety of people associated with the project. Each letter briefly describes a real situation and requests the issuance of a change order.

The group is then required to classify each request as a:

- Change within job scope, including
  - Design/process development
  - Estimate adjustments
  - Other...engineering/field development and minor execution changes
- Revision of scope or basis (i.e., outside scope of the contingency built into the estimate)
- Extraordinary random event (i.e., force majeure, termination or suspension of work, etc.), or
- Non-change (i.e., corrective action required to meet the job specification).

Once the classification of the requests is complete, the group is then asked to detail the logical next steps in processing each of the four classifications. The group must, as a result of this requirement, examine the contract documents supplied for those parts that apply to the administering of changes. They are also required to suggest methods to facilitate the handling of those requests that are not deemed design changes. By virtue of this requirement, the attendees are not only exposed to relevant parts of the standard contract documents but will also take with them an enhanced understanding of the entire change process.

The next portion of the problem exemplifies the "ripple" effect changes have on projects. The attendees are asked to list the personnel and steps, for both the PM Team and the Contractor, that will be required if one of the requested changes is processed. They are also asked to rate the impact of the change as large or small. This portion illustrates that for even a relatively small design change, the effect on the project is rather large.

The contract, although the basis of control on a project, cannot possibly spell out every situation that may arise. The change procedure is one section that has several "grey" areas. This, in turn, makes the writing of a solution to this problem much more difficult than the formulation of the problem itself. Fortunately, the author has had the benefit of the expertise of several senior EEPM engineers to clarify those "grey" areas.

The solution conveys, in a relatively limited amount of space, information received during many lengthy discussions on what "really" happens with design changes on an ongoing project. The solution to the Changes Problem presented in Attachment No. 1 represents a detailed, contractual look at the processing of each of the four classifications; i.e., changes within job scope, revision of scope or basis, extraordinary random events, and non-changes. Also presented are the explanations of the "grey" areas that are inherently included in the contractual documents concerning changes.

This problem is a perfect example of the cross-fertilization that must exist in any ongoing company. Through it, some one hundred years of cumulative experience will be relayed to the Seminar attendees.

Piping Layout

Appraisal of a contractor's efforts in both the design and construction of a capital project is the major function of the Project Management Team. During the design portion of a project, Project Engineers are delegated certain responsibilities for monitoring the execution contractor's organization, plans, and performance in the broad areas of detailed design, drafting, procurement, cost control, scheduling, and other engineering efforts.

The Project Engineer, through his appraisal efforts, can effectively reduce the total capital outlay necessary to build an operating plant. The individual problem presented illustrates the cost-cutting effect a Project Engineer can have on the piping layout of a plant. This problem is extremely relevant in the light of a typical petroleum refining project where as much as fifty percent of the cost of the plant is in piping.

At first glance, it appears that a piping specialist would be necessary to solve this problem. It is precisely this point that makes this problem so valuable.

The attendees are given the logistic boundaries in which they must work and a contractor's proposed piping diagram. From this they are required to re-route the existing piping so that it still functions but material and construction costs are reduced. Again, in an effort to present this problem in a realistic manner, the proposed piping diagram has been extracted from a larger flow diagram that originated in a contractor's office. The dollar values used are current and the additional information given to set the scene is an accurate description of the situation that existed on the project from which the data have been drawn.

In approximately thirty minutes, the attendees discover that it is possible to save substantial sums of money by simply being inquisitive, i.e., asking why it has to be this way or that way. The problem is not intended to produce piping experts, but it does show the attendees that economy of design can be a relatively simple task that requires an inquiring mind. The complete solution is shown in Attachment No. 2.

Over the course of the first module, sixteen problems have been developed, seven group and nine individual. With each of the problems, the last phase in the development process consists of validating the problems. The validation has been accomplished using a procedure consisting of three steps.

The first step in the validation process of the problems is establishing face validity. To achieve face validity, the material to be evaluated is given to a person judged competent in the field. Because this person has achieved mastery in the field which the problem concerns, he should be able to work the problem without prompting. If prompting is necessary, face validity is ruled out and the materials are revised to reflect the prompts.

This process is continued until a master performer can manage the materials without any prompts. Once face validity is achieved, the materials are ready for testing on the intended audience. Developmental testing, the controlled testing of a few persons thought to represent the intended audience, is the second step. Prompts are given by the author until the subjects can work the problems. These prompts are then incorporated into the revised materials.

The third step, field testing, will be initiated when the revised Seminar is presented for the first time at Florham Park. The developed materials will be given to the intended audience along with feedback instruments designed to evaluate their response to the materials. These data will be collected and analyzed. After final revision, the materials will be considered validated for that audience, i.e., the PM Seminar attendees.

- Startup Teams
- Non-Process Quality Control (NPQC Engineers)
- Purchasing Department Managers
- Producing Department Managers
- Basic Practices Committee
- Contractors
- Other Chemical Companies

One of the major recommendations resulting from this study was the establishment of the Quality Control Division (QPSD) to unify the fragmented, ill-defined quality assurance system that existed at that time. It was believed that with time, this unified program would lead to an upgrading of quality control on major projects.

The newly formed division consisted of three established sections and one new one, Quality Control Systems. The QC Systems Section's primary responsibilities consisted mainly of toolmaking and establishing systems, procedures, and indices.

The QC Systems Section was at that time, mandated to develop several innovative systems to assist in the quality control function on major projects. The mandates were:

- Develop a materials quality trend monitoring system. This system should be based on obtaining timely feedback from inspectors and project management teams to identify problem areas and on implementing corrective measures on all ongoing projects. A toolmaking program should be instituted which draws upon this and other available data to measure changes in material quality on a world-wide basis. This should highlight potential quality problems as they are developing so that broad countermeasures can be taken when deemed appropriate.

- Develop performance monitoring systems and indices which identify areas where various Exxon Engineering functions can be improved.
- Establish (or improve) systems for appraising and monitoring vendor quality control systems and develop ways to improve these systems when needed.
- Establish (or improve) systems for appraising and monitoring contractor quality control procedures, giving special consideration to the problems associated with large, complex projects.

In response to these mandates, the QC Systems Section undertook an extensive toolmaking project designated the Material Quality Information System (MQIS). This system provided "hard" data on material quality worldwide. The following is a brief description of the extensive and powerful vendor quality monitoring/control tool, MQIS.

The MQIS is an interactive computer graphics program used to analyze and report on data from an extensive material quality data base maintained by EEPM's Quality Control Division. This data base contains detailed records of all ER&E Inpsection experience worldwide since the latter part of 1976. Records of all Inspection manhours spent and detailed coded descriptions of all defects found on approximately 5000 new purchase orders per year are stored on a month-by-month basis in this computerized data base.

The MQIS permits interactive graphical and tabular analysis of these data along many different dimensions. The user specifies the commodity, project or projects, geographical source of materials, and/or vendors of interest for analysis. The time span, the type of defect, and the type of statistical analysis desired (e.g., trend curve, best-fit curve, data scatter) are also specified by the user.

The user then views the graphical output requested on the screen of a CRT. The material quality indicators and statistics presented permit the systematic identification and investigation of quality trends and problems. The ability to operate in the interactive mode with immediate response as well as the flexibility of the analytical tool permits a rapid definition and analysis of material quality problems.

The MQIS has been used successfully by Inspection as a tool for analysis of inspection approaches and in the allocation of inspection resources. It has also been highly beneficial on project work for material quality trend monitoring and control. It is now in the stage where material quality trend prediction may be attempted.

The MQIS data base software forms the basis for the development of the Field Quality Information System (FQIS). The development of FQIS has also been in response to the mandates put forward by the Materials Quality Control Study. Its scoping and development combine to make a major toolmaking item in the QC Systems Section's 1982 budget, and the major portion of the author's second internship module.

FIELD QUALITY INFORMATION SYSTEM DEVELOPMENT

The Field Quality Information System as defined in the 1979 budget "should be a new data collection system for all defects/errors found in the field by Project Management Field Teams and computerized data analysis system (similar to MQIS) to quantify the level of field quality problems and analyze trends."

Even with this broad charter, limited manpower delayed the initial scoping and development work until the beginning of 1982, at which time the author joined the QC Systems Section. Interpreting this charter as the go-ahead for development of an extensive system to handle many of the quality related functions on construction projects, the following major areas have been considered for inclusion therein:

- Defects in vendor supplied items (Field MQIS)
- "Rework" tracking
- Safety statistics
- Cost control
- Change orders, extra work items, etc.
- Equipment deliveries (including stage of manufacture)
- Schedule control
- Weld defect tracking
- Subcontracts

The author's primary involvement with the initial development of FQIS has been in the "rework" tracking portion, although in a broader sense, the author has had input into the entire scoping effort.

The concept of segregating rework from direct labor was developed on the Baytown Fuels Expansion Project (BTFE) and carried over to the Baytown Olefins Plant Project (BOP). At the outset of the BOP construction effort, the BTFE developed rework tracking procedures were implemented on BOP via a "Field Variance" procedure. The contractor's cost group held meetings with craft supervision to explain the procedure and its potential value to them and the project. This early indoctrination generally resulted in the crafts accepting the concept as a means of expressing their own particular work execution difficulties to both the contractor and Exxon Project Management.

Segregation of rework has several advantages over the alternative of considering all labor "direct". A primary benefit to the project is earlier identification of the nature and magnitude of difficulties encountered by field forces. Clearer knowledge of the character and impact of problems aids the crafts, contractor management, and Exxon Project Management in effectively addressing such problems in a timely manner. A benefit, which becomes apparent later, is in craft manpower planning. Manpower required to execute normal work can be fairly easily forecast, but knowledge of manpower required for out-of-scope work is not obvious without historical data and accurate rework tracking. Awareness that rework will run 30% or more in latter stages of activities can help to avoid overly optimistic forecasts and field manning plans. Obviously, segregation of rework grossly alters productivity profiles by reducing the sharp decay late in the activity. This segregation allows a clearer assessment of true productivity. Field forces also feel more accountable for their productivity when problems created by "the other guy" have been eliminated from their productivity assessment. Rework can be readily recombined with direct labor if comparison to traditional productivity profiles is desired.

BOP generated approximately 10,000 "Field Variances" over the life of the project. These variances form the basis on which the initial rework portion of FQIS has been structured because it is felt that the BOP rework data fairly represent the experience of an average project.

Each field variance was documented and categorized on the job site as Exxon, Engineering, or Construction rework according to the following criteria:

Exxon Rework

- Is not specifically required by the job specifications in effect when the item originated. (Items merely "suggested" by the specifications or resulting from late revisions or interpretations of specifications can be considered Exxon rework.)
- Is not shown on engineering drawings from Exxon. (Items shown on drawings which are not budgeted should be addressed by a change order if they are significant.)
- Is requested by Exxon, usually by a Field Action Memo (FAM).
- Is not required by normal construction practices used to ensure the quality of the work.
- Results in additional costs.
- Is not budgeted in the contractor's control document
- Is not required to rectify a construction deficiency.

Engineering Rework

- Is the result of an engineering error, such as incorrect or incomplete drawings, or specifications differing from Exxon's original requirements.
- Is the result of procurement deficiencies.

- Is not the result of Exxon requested changes or additions.
- Is not the result of vendor deficiencies. (These should be backcharged.)

Construction Rework

- Is the direct result of a contractor's field error, whether originated by supervisors or the craft involved.
- Is not the result of faulty contractor craftsmanship, such as defective welds, bad cable, or pipe connections, etc. (These hours must be absorbed within the respective direct accounts.)
- Is not the result of a material defect. (These may be backchargeable.)
- Is not the result of a design deficiency or change.
- Is not the result of a scheduling or delivery problem.
- Is not the result of a procurement deficiency.
- Is not the result of a contractor decision dealing with the sequence of construction activities.

In order to make FQIS an effective tool capable of quantifying levels of field quality problems and analyzing trends, further breakdown of the broad divisions of rework is necessary. To accomplish this, many of the thousands of field variances have been read and compiled according to similarities. This has resulted in a level of categorization necessary to identify quality problem areas early and initiate corrective actions on an ongoing construction project.

Exxon Rework has been broken down into three major categories with sub-categories as needed. The first category under this division is Design Enhancement. In order for a variance to be classified as a Design Enhancement, it must be a design improvement originating from Exxon, specific to one work item as opposed to a more general improvement to be implemented plant wide. It must be accompanied by a Field Action Memo that specifically indicates one of the following sub-categories as justification for the enhancement:

- Safety improvement
- Operability improvement
- Maintainability improvement
- Other improvements not specifically covered by safety, operability, or maintainability, but can be construed to be a design enhancement.

The second category in this division, Additional Exxon Requests, is for rework that cannot normally be considered a design enhancement but nevertheless is still considered Exxon Rework. The request must be accompanied by appropriate justification and documentation. Additional Exxon Requests has been broken down into the following sub-categories:

- Aesthetic improvements
- Additional equipment testing/inspection
- Assistance to owner
- Other

The third and final category in Exxon Rework, Specification Enhancement, includes those improvements to the design, originating from Exxon, that are to be implemented plant wide, i.e., in every location in the plant where that particular improvement is construed to be necessary. No further breakdown of this category has been done because it is felt that the number of variances that fit this description will be relatively few.

Engineering Rework is also divided into three major categories. However, due to the complex nature of this type of rework, there are more sub-categories and even several sub-sub-categories.

The first major category, Procurement/Purchasing Deficiencies is broken down as follows:

- Incomplete information supplied to a vendor/subcontractor

  This sub-category includes those items a vendor supplies that do not meet the minimum acceptable quality of the owner; however, the fault does not lie with the vendor. The vendor lacked sufficient information to manufacture the item to acceptable quality, i.e., applicable BP's, drawings, instructions, etc.

- Wrong quantity or type material ordered

  This sub-category includes those items that are of acceptable quality but of wrong quantity or type, i.e., no material or not enough material ordered. An example of this type of Engineering Rework is wrong packing or trim on a valve.

- Other

  This sub-category includes any other procurement/purchasing deficiency that is not specifically included in the above sub-categories. However, it does not include delays caused by late deliveries of vendor supplied items.

The second major category in Engineering Rework, <u>Design Deficiencies</u> is broken down into five sub-categories as follows:

- Omissions

  This sub-category embodies design omissions detected in the field that require additional detail engineering. This category includes, but is not limited to, items shown on Exxon Engineering flow sheets but not shown on a contractor's drawings; items shown in contractor's specifications but not present in the contractor's detailed engineering; items shown on a general arrangement piping diagram or piping model but not shown on isometrics. In general this category includes items or instructions shown on a general document but not present on a detailed document or drawing.

- Incorrect dimensions

  This sub-category is for dimensional errors usually realized in the field at time of erection. It does not include misfabricated items, i.e., fabricated as shown on the shop drawings but not constructable. Examples of this category of rework include errors in lengths of spool pieces, diameters of pipe, etc.

- Physical interference/mismatch

  This sub-category is divided into two components as follows:

  - Between contractor engineered items; for interference or mismatch occurring at a construction interface between items designed by a single engineering contractor. This category is intended to detect problems arising from the lack of adequate internal information flow between the engineering disciplines of a single organization. Examples of this type of rework include instrument installations designed to be located where process pipe must run, union of pipe flanges not possible due to existing foundation corner, etc.
  - Between vendor-contractor or contractor-contractor engineered items; for interference or mismatch occurring at a construction interface between items designed by more than one engineering organization, either separate

engineering contractors or a contractor and a vendor. This category indicates internal communication problems arising when an engineering contractor is required to incorporate information originating from a vendor or another engineering contractor into a design package. Examples of this type of rework include anchor bolt patterns on a pump or tower base which do not match anchor bolt placement on the foundation; piping on a package unit which is not the same type or size as interface piping from the plant, etc.

- Inconsistency between drawings

  This sub-category is for drawing errors detected in the field that are due to inconsistencies in contractor-generated drawings and it is not clear which drawing is correct. These errors include, but are not limited to, items left off one drawing but shown on another, items common to several drawings that are not shown in the same location such as coordinates for a foundation that are different on two separate drawings.

- Other

  This sub-category is for design deficiencies related to safety, operability, maintenance, or accessibility. It also includes any other design deficiency not explicitly included in one of the above categories. Rerouting of a process line so that a control valve can be accessed or the addition of a safety cage to a ladder are two examples of this type of rework.

The third and final major category of Engineering Rework, Late Design Revisions is for issued drawing revisions that affect work installed under an approved for construction drawing. The revision must originate in the engineering office and not be a result of a field-reported problem or a change order. This category is divided into the following two parts:

- Late addition/deletion

  This sub-category is for late revisions that specifically add to or delete from work originally included. It does not include the mere rearrangement of materials.
- Other

  This sub-category is for any other late revision besides a specific addition/deletion.

Construction Rework is divided into five major categories. The inherently diverse nature of the field variances for this type of rework preclude easy collection with less than five major categories.

The first major category under Construction Rework, Lost Material is for those materials that arrive on the jobsite but are subsequently lost. This includes material that cannot be located in a warehouse or material that is signed for and then lost. These are not the only instances of lost material; however, they are good examples of the type of variances that belong in this category.

Accidental Damage, the second major category for Construction Rework, is for material or equipment unintentionally damaged in one of the following situations:

- During storage (after vendor delivers to site)
- In field fabrication shop
- During onsite transport (including loading/unloading equipment onsite)
- During erection/construction
- Post erection/construction
- Other (not specifically identifiable as one of the above but identifiable as accidental damage)

The Interference Between Crafts category includes rework caused by the intentional removal or damage of a craft's installed work so that another craft may proceed with their work. The removal of installed work cannot be the result of any type of engineering rework or change order. This category primarily identifies construction sequence problems.

Field Fabrication Error, the fourth major category, consists of rework due to the incorrect fabrication of an item in a field fabrication shop. To be classified as a Field Fabrication

Error the shop drawings must be correct and the rework cannot be due to poor craftsmanship.

Installation Errors, the fifth and largest of the major categories, consists of the following sub-categories:

- Misalignment, i.e., out of plumb, out of tolerance, etc.
- Wrong orientation

  This sub-category includes items or equipment installed backward or upside down. The most prevalent example of this type of rework on BOP was check valves installed to check flow in the wrong direction.
- Faulty Layout

  The rework that this sub-category is primarily intended to track is field engineering type errors, often surveying related. The typical type items included are; built out of square, built correctly but in the wrong location, and built at the wrong elevation.
- Wrong Items

  This sub-category is for rework caused by the wrong piece of equipment or material being installed, i.e., right place but wrong thing, such as the wrong grade wire pulled through conduit or the wrong type of valve installed for the particular service requirments.

- Other

  This sub-category includes any other installation error not specifically classified as one of the above types of construction rework.

In addition to Exxon, Engineering, and Construction Rework, there are three other areas connected with rework that are pertinent enough to track. The first area is one labeled Insufficient Information to Categorize. These items may be identifiable as Engineering, Construction, or Exxon Rework, but no further breakdown is possible with the information originally supplied. This type of tracking can indicate the crafts that may not understand the system or are not sufficiently describing the rework being requested for other reasons. Special attention should be given to the various "other" categories to ensure that no insufficient information type items are coded incorrectly.

Another important area to be tracked as part of the rework portion of FQIS is Coding Changes. This category is intended to track rework originally coded as one type but subsequently changed to another type. This tracking facility gives an indication of the understanding of the coding system and also indicates possible "featherbedding" by the crafts.

The last area connected with rework to be tracked is Rework That Should Be Direct Work. This category, as with the previous two, is intended as an internal and external check on the integrity of the data being collected.

As discussed previously, the primary function of EEPM is one of stewardship on behalf of Exxon operating affiliates during the various stages in the development of major capital projects. One of the most important responsibilities of this stewardship role is the assurance of technical quality in the finished project. This quality assurance role extends well beyond the traditional bounds of material quality control to include the quality of both the engineering and the construction which go into creating an operating plant.

Both the detailed engineering and the construction phases of a project are handled by major international contractors on large Exxon capital projects. EEPM's stewardship role thus involves a considerable amount of work in the monitoring and evaluation of the contractor's efforts. While EEPM employs a number of sophisticated methods for doing this work, there has existed a need to develop and implement a comprehensive quality information system to assist the EEPM project team to better monitor and control the quality aspects of the project execution.

Toward this end, the scoping and development of the FQIS is intended to fill this need through the use of interactive computer database technology in conjunction with a well-designed, standardized project information feedback system.

The primary challenge in designing this tool involves the constraints levied upon it by Exxon Engineering's approach to project management. That is, EEPM does not impose its control systems on its contractors and large incremental data collection systems are generally resisted. Thus to be successful, the FQIS must be able to function with something of a "universal language".

This step in designing the FQIS has involved research on the part of the author and the other system developers into the field control systems used by the contractors. The author has brought his academic training to bear on this task and by participating in this scoping effort, has contributed to a sound design basis for the system. At the same time, the author has developed an excellent first-hand knowledge of how project management systems function in the field.

VENDOR MATERIAL QUALITY

INTRODUCTION

The previous module of the internship program on contractor quality subsumes aspects in the critical area of material quality. Because of its critical nature in the successful creation of an operating plant, a single module has been devoted to this subject in the internship program. The aim of this module has been to involve the author in key stages of the material quality control process.

At EEPM, material quality control is based on the concept that early QC efforts, many of which precede the manufacturing stage in the material order life cycle, are far more effective in assuring the quality of the end-product than later crisis management activities. Accordingly, much effort goes into activities such as preinspection meetings with major equipment vendors. Also, using a variety of sophisticated computerized information systems developed in-house and supported by worldwide Exxon purchasing and inspection experience, detailed vendor and material quality analyses can be performed during the early stages of an order. The results of these analyses can then be used to control future events as past experience is learned from.

Exxon Engineering Inspection, in conjunction with the project management function, provides a comprehensive in-plant quality assurance program on behalf of the owner's representative.

The EE worldwide staff of inspectors, for over fifty years, has been active in monitoring and assessing manufacturers' quality control of materials and equipment on Exxon's major projects. EE Inspection has the capabilities and resources to inspect materials and equipment anywhere in the world through the use of both its own inspectors and the services of contracted, qualified inspection agencies and their individually qualified inspectors.

The author has been involved in a variety of material quality assurance/control activities during this module of the internship. These activities primarily have fallen into three distinct areas within the realm of the Inspection Section of the Quality Control Division:

- Vendor qualifications
- Preinspection meetings
- Shop inspection

PREINSPECTION MEETINGS

The preinspection meeting is the implementation of the basic Exxon Engineering philosophy of "Preventive Inspection", i.e., a cooperative effort by the purchaser, the vendor, and the inspectors to anticipate and prevent problems which might result in costly repairs and delivery delays for the equipment involved.

It also establishes a working interface between the vendor's supervisors involved in production and possibly engineering and the purchaser through the Exxon Inspection representative, if this interface does not already exist. In most cases, the purchaser's previous contacts have probably been with the vendor's sales staff and engineering.

The specific objectives of the preinspection discussion include the following:

- Establish inspection requirements;
- Avoid having to make rejections, particularly "last minute" ones as the work proceeds;
- Identify conflicts** between order requirements and that which the vendor plans to provide. These conflicts primarily relate to:
  - The materials specified
  - The manufacturing/fabrication methods
  - The examining and testing requirements for the commodity and its components

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**Explanatory Note: Conflicts may be generated by order requirements not recognized when the vendor bid on and obtained the order. It is not unusual, when bidding competitively, for a vendor to submit a quotation based on a standard or unit price without taking time to analyze the purchaser's order and its attachments. As a result, tests required by EE Basic Practices are often overlooked and not included in the quotation. These omissions are not disclosed until the preinspection meeting is held. The vendor then attempts to recover his costs by asking for extra charges and pleading potential production delays because of the quality control being applied.

- Make the vendor aware that Exxon Engineering Inspection or its agent will conduct inspection as required, at the vendor's or sub-vendor's plant in accordance with the order requirements and its applying specifications;
- Develop the timing of the inspection; and
- Report the results of the meeting to the project management team/owner and contractor.

In the case of shops which are new to ER&E, another objective is to evaluate the safety aspects for the guidance of inspectors on future visits. This includes the availability of personal protective equipment.

Not all purchases require preinspection meetings. This decision is made by the project management team or the responsible Exxon Regional Inspection Office. However, it may be influenced by a request from the client, the contractor, or the vendor.

Formal preinspection meetings normally are conducted for an order on equipment that:

- Is large, complex, or expensive;
- Has complex customer specifications;

- Involves numerous sub-order items or equipment requiring source inspection per EE Basic Practices;
- Involves a vendor not recently used or an unknown vendor;
- Requires extensive fabrication or unusual material;
- Involves critical testing or inspection procedures; or
- Is a critical delivery item.

Additionally, preinspection meetings are conducted when, based on past experience, it is anticipated that the vendor may deviate from the order requirements.

The author has participated in a preinspection meeting at Ingersoll-Rand's Cameron Pump Division in Phillipsburg, NJ. During this meeting, the specifications for a multi-stage, centrifugal pump were discussed. The necessity for the meeting became obvious as the specifications were covered. There were several points contained therein that Ingersoll-Rand had overlooked.

Similarly, when the question of quality control for the impellers was raised, the IR representative guided the meeting into the foundry at the plant and demonstrated IR's ability to cast the impellers in question using ceramic molds. With this type of casting, it is not only possible to control the intricate patterns and thicknesses required, but also the finish on the impellars. This demonstration thoroughly convinced all present that the quality required by the specifications could indeed be met.

VENDOR EVALUATION

Vendor evaluations provide information pertaining to the capability of manufacturers to supply materials and equipment used in the construction of refineries, chemical plants and other facilities for Exxon Corporation Affiliates. This information resides with Exxon Engineering's Inspection Systems Section. The collecting, maintaining, and distributing of the data rests with the Inspection Systems Section because the inspection area has continual association with the various vendors.

The fact that a design has successfully met its qualification tests does not prove that the subsequent production will be of adequate quality. This quality depends on the vendor's manufacturing capabilty. The risks involved have led Exxon to adopt the concept of vendor "surveys" (or "assessments") as an early warning device.

Under this concept, Exxon Inspection sends a team to visit the vendor's manufacturing facility to secure assurance that the vendor will deliver a good product. The survey team examines various aspects of the facility and reports what they feel is most likely to happen. All survey teams use similar checklists, with the usual points of concentration being:

- Management capabilities

  These relate mainly to such matters as:

- Policies. Is the vendor willing to be "on the team", i.e., operate on the basis of exchange of visits, no secrets, joint planning, mutual technical assistance, etc.? Does the vendor engage actively in quality improvement and cost reduction?
- Organization. Have the activities essential to attainment of quality been identified and described? Are these activities clearly assigned to the various departments in a logical relationship?
- Personnel. Have the managers, specialists, and workforce been trained in modern ways as evidenced by structured courses and certificates of qualification? Are there clear evidences of high motivation for quality in relation to the other parameters (cost, delivery, etc.)?

• Technological capabilities

Here the emphasis is on matters such as:

- The facilities and equipment in the vendor's plant, plus their up-to-dateness and condition;
- The ability of the manufacturing process to make the product to the specifications;
- The degree of understanding of the relationship between process variables and product results; and
- The adequacy of the measuring and testing equipment.

The ability of the process to make the product to specifications is one of the most essential aspects of quality assurance in the entire vendor survey concept. The best predictor of whether the process can do a quality job is evidence that it has already done so on a similar product. Lacking clear evidence of such prior performance, reliance can be placed on process capability studies. Lacking either of these, any prediction of the vendor's future quality is largely subjective.

- Quality discipline capabilities

  Here the emphasis is typically on quality-oriented systems and procedures. These include systems for process control, product inspection and testing, data recording and summary, documentation, maintenance of test equipment, etc. In addition, this part of the survey looks for the existence and completeness of quality manuals as well as provision for audit of conformance to systems and procedures.

Within Exxon Inspection, there is a huge body of experience concerning the use of vendor surveys and it is clear that there are both merits and limitations to them.

- Merits

  All surveys provide, to some extent, objective information.

The most obvious concerns the physical facilities - what type, how many, what condition, etc. Where certain essential facilities are not in evidence, e.g., a special type of test equipment, the buyer is alerted to the extent of delays which might result.

The survey may turn up additional findings of an objective nature - the presence or absence of essential training programs, traceabilty provision, data feedbacks, etc. Such findings also give early warning as to the time and effort required for the vendor to prepare himself to meet the provisions of the contract.

The survey also has the merit of opening up communications between buyer and vendor, and even within the vendor organization. There have been instances in which survey findings have stimulated vendor upper management action on matters which the vendor's own quality manager has been unable to communicate to the top.

- Limitations

  Application of the survey concept can create extensive duplication of surveys throughout the buying and vendor companies. Such duplication is very costly to both buyers and vendors. In particular, small vendors face serious problems because of processions of visitors from numerous buyers, each demanding much time and attention.

The Inspection area of EEPM feels that the most promising way to reduce the cost of vendor surveys and predict future quality is to pool data in what is known as a Vendor File. The Vendor File is an indexed collection of the names of approximately 9,000 vendors, and the rating of the capability of each to make one or more types of equipment. This file is backed up, in part, by surveys of plant facilities, as well as other information sources, such as inspection reports, advice from affiliates, project management feedback, and EE consulting reports. Vendors are rated acceptable as a result of these surveys. They maintain this acceptability by continued satisfactory performance.

This method of pre-qualifying a vendor reduces costs considerably, especially when buying a piece of relatively standard equipment. It also increases the probability of procuring the services of a "qualified" vendor for any given piece of equipment and that vendor supplying a quality product.

Information in the Vendor File is available on a demand basis from ER&E and is distributed semi-annually to purchasing departments of the affiliates. This information is regarded as highly confidential and is generally supplied strictly on a need to know basis.

The author has participated in the vendor evaluation process via vendor surveys at both of the following facilities:

- Allis-Chalmers Turbine Division, York, Pennsylvania
- Birdsboro Corporation, Birdsboro, Pennsylvania

The survey in both cases was intended to determine each vendor's capability to manufacture a specially designed, intricate seal for a retort process for a synthetic fuels project. These surveys provided the opportunity to examine two different approaches to the same problem. One vendor's approach was to fabricate the seals and runners from plate steel and machine in the intricacies. The other proposed to cast the seals with its intricacies and only finish machine for tolerance. As with the preinspection meeting, this process involved a tour of the respective vendors' shops.

It appears, upon completion of both surveys, that the better choice in this case will be to cast the seals and runners so that the machining process can be carried out with less effort. The metallurgical qualifications of both methods are roughly equal in this particular instance.

SHOP INSPECTION

Inspection consists of conducting, in sequence, one or more distinct acts of examination and test of a material, item, or equipment, in such a way as to determine if it complies with the requirements of the purchaser's order and has the quality of workmanship to satisfy the specified service it is expected to withstand. Although quality cannot be inspected into a product, the following list indicates some of the examinations and tests that EE Inspection employs in checking to see that quality is built into the product.

- Monitoring the effectiveness of a vendor's quality control technique
- Evaluating a vendor's quality standards, which may lead to establishing stricter acceptance norms if the existing ones are considered inadequate
- Destructive and non-destructive tests
- One or more forms of mechanical or electrical tests
- Mechanical running and performance tests
- Review of documented data covering tests not witnessed
- Surface examinations
- Dimensional checks

EE Inspection performs several roles during its inspection activities. One, obviously, is assuring that the product meets the purchase order requirements by monitoring the vendor's activities relating to the quality of the product. Another is to confirm, or perform additional inspections supplemental to the vendor. A third role is to work with the vendor to identify conditions that could cause costly repairs or delays during manufacture/fabrication.

Throughout the third module of the internship, the author has participated in shop inspections throughout New Jersey, Eastern Pennsylvania, and New York State. These inspections primarily fall into three classifications:

- Complete inspections
- Partial inspections
- Final inspections

Complete inspection involves inspection on a progressive basis. It is normally reserved for those items where it is difficult, if not impossible, to examine the finished product and determine if the desired quality has been built in. Large towers or drums, reactors, heat exchangers, boilers, furnace coils, airfin exchangers, and rotating equipment normally require complete inspection.

Partial inspection means that some of the interim examinations performed during a complete inspection are omitted. The purchase order generally specifies what examinations are necessary and expected. In some cases, circumstances at the point of supply limit the amount of inspection possible. Partial inspection may be accomplished using a sampling technique, adjusting the sample size to compensate for the amount of defective material found.

Final inspections are usually visual and dimensional checks with a review of test data and/or mill certificates. They are normally specified when past experience indicates that looking at the finished article is enough to determine if the necessary quality has been supplied and the order requirements met.

PROPOSED INSPECTION METHOD ENHANCEMENT

Throughout this module of the internship, the author has been exposed to both the various methods and procedures used by EE Inspection and the current concerns relating to the future needs of the organization.

Two concerns of great interest to EE Inspection are the cost of their service and the timeliness of their reporting. With these in mind, the author has proposed a method that may potentially reduce both via a more streamlined approach to reporting. This proposal involves the use of portable, hard-copy terminals for a limited trial with field personnel.

The EE inspectors presently file their reports by mail or through recorded telephone messages (Code-A-Phones). Both of these procedures, though functional, inherently cause delays in the reporting process of EE's Inspection Section. Both the written reports and the Code-A-Phone messages are currently logged into the INSPECT System, typed, edited, retyped, and finally issued. Although not the norm, this process, from inspection to formal issuance of a report, may take upwards of one month to complete.

Using the proposed method, the inspector will file his report, via a terminal and a telephone, the same day he inspects the commodity. This report can then be edited on the screen of a CRT here at Florham Park and sent to an on-line printer. The report will be in the mail to the client the day following the inspection. This procedure will eliminate the lengthy delay now being experienced, reduce much of the unnecessary typing time at the home office, and provide a direct link to the INSPECT System via the computer.

Once this concept has been tested, there appears to be no reason the various agencies used by EE Inspection cannot be brought on stream and file their reports similarly.

An additional benefit of this system, is the fact that the terminal can communicate in both directions. This ability facilitates information distribution to field personnel and may provide an instant communication link between the Regional Inspection Offices and the Project Inspection Coordinators to transfer inspection information and INSPECT input.

Using the Interactive Computer Facility presently in existence in the Quality Control Division, a test program has been developed to test the concept of remote data entry for inspection reporting. To accomplish this, a simple interactive program has been written that will permit the Inspector to:

- File Short Form Reports
- File Release/Rejection Notices
- Send messages
- Receive messages

Over a six month period, two inspectors will use portable terminals to communicate with the home office. This will allow the concept to grow and develop with time. Once the possibilities have been identified, it is anticipated that major toolmaking effort will be allocated for formal development of a comprehensive system.

ADDITIONAL TRAINING ACTIVITIES

Throughout the internship, the author has been involved in various training activities other than those specifically set forth in the objectives. The major portion of these activities has been in conjunction with the PM TrainEE Program.

In summary, the basic precept of this program is the accelerated development of skilled project management manpower from inexperienced engineers. This objective is accomplished by early and intensive exposure to hands-on training within Exxon affiliated refineries. Additionally, the TrainEE's are exposed to relevant training courses presented at ER&E, Florham Park. These courses are presented quarterly.

The home office technical education program for the ER&E Project Management TrainEE's is structured as follows:

- Session 1
  - Cost and Schedule Concepts and Practices
  - Cost and Schedule Techniques used in Project Activities
  - Basic Engineering Economics
  - Contracts Engineering
  - Introduction to Basic Practices
  - Safety Engineering: Concepts and Practices

- Session 2
  - Project Engineer's Manual: In-Depth Review
  - Field Engineer's Manual: In-Depth Review
  - Coordination Procedure: Basic Documents for EE Managed Projects
  - Petroleum and Chemical Processes
  - Fire Training
  - Safety Update
- Session 3
  - Writing in Research and Engineering
  - Onsite Design Survey Course
  - Introduction to Exxon Engineering
  - Company Expense Statements
- Session 4
  - Materials Engineering
  - Exxon Engineering Inspection
  - Design Practices Introduction
  - Overview of Exxon Engineering Assignment Policies
  - EE Workload and Project Outlook
  - Safety Update
- Session 5
  - Project Management Seminar

In addition to the PM TrainEE Program, the author has participated in EEPM Safety Audits of the Clinton, New Jersey New

Facilities Complex. These audits have included site walk throughs, interviews, and a thorough review of contractor records.

The author has considered these and the various other training type activities to be an extremely relevant and beneficial portion of the internship.

SUMMARY

The author feels that the objectives set forth prior to the beginning of the internship have been fulfilled most effectively. The variety and breadth of the internship has provided a unique and invaluable framework upon which to build a career.

The preparation received during the academic portion of the Doctor of Engineering Program has served to accelerate both the orientation process and the subsequent learning experience at Exxon Research and Engineering Company. The professional development and business course work has provided a base useful to the author while observing and participating in the highly complex energy business. The technical preparation has enabled him to adapt quickly to the Exxon Engineering Project Management concepts and to put these concepts to use in solving the various problems presented during the internship.

Throughout the internship, the members of the Quality Control Division have been most helpful and encouraging. Exxon Research and Engineering Company has admirably fulfilled its portion of the internship. The author feels that the internship has indeed been profitable for both parties.

FIGURE 1

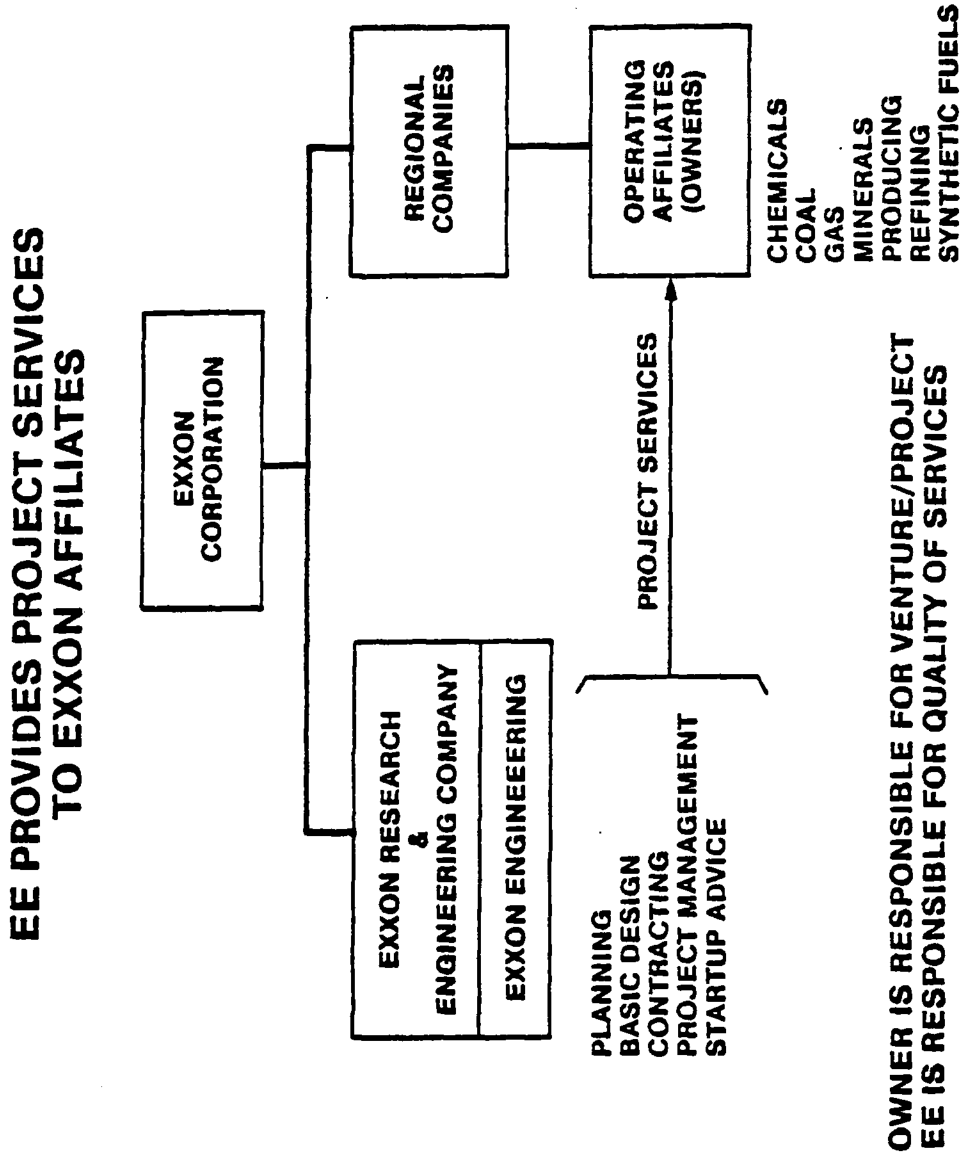

EE PROVIDES PROJECT SERVICES
TO EXXON AFFILIATES
EXXON CORPORATION
EXXON RESEARCH & ENGINEERING COMPANY
EXXON ENGINEEERING
REGIONAL COMPANIES
OPERATING AFFILIATES (OWNERS)
PROJECT SERVICES
PLANNING
BASIC DESIGN
CONTRACTING
PROJECT MANAGEMENT
STARTUP ADVICE
CHEMICALS
COAL
GAS
MINERALS
PRODUCING
REFINING
SYNTHETIC FUELS
OWNER IS RESPONSIBLE FOR VENTURE/PROJECT
EE IS RESPONSIBLE FOR QUALITY OF SERVICES

FIGURE 2

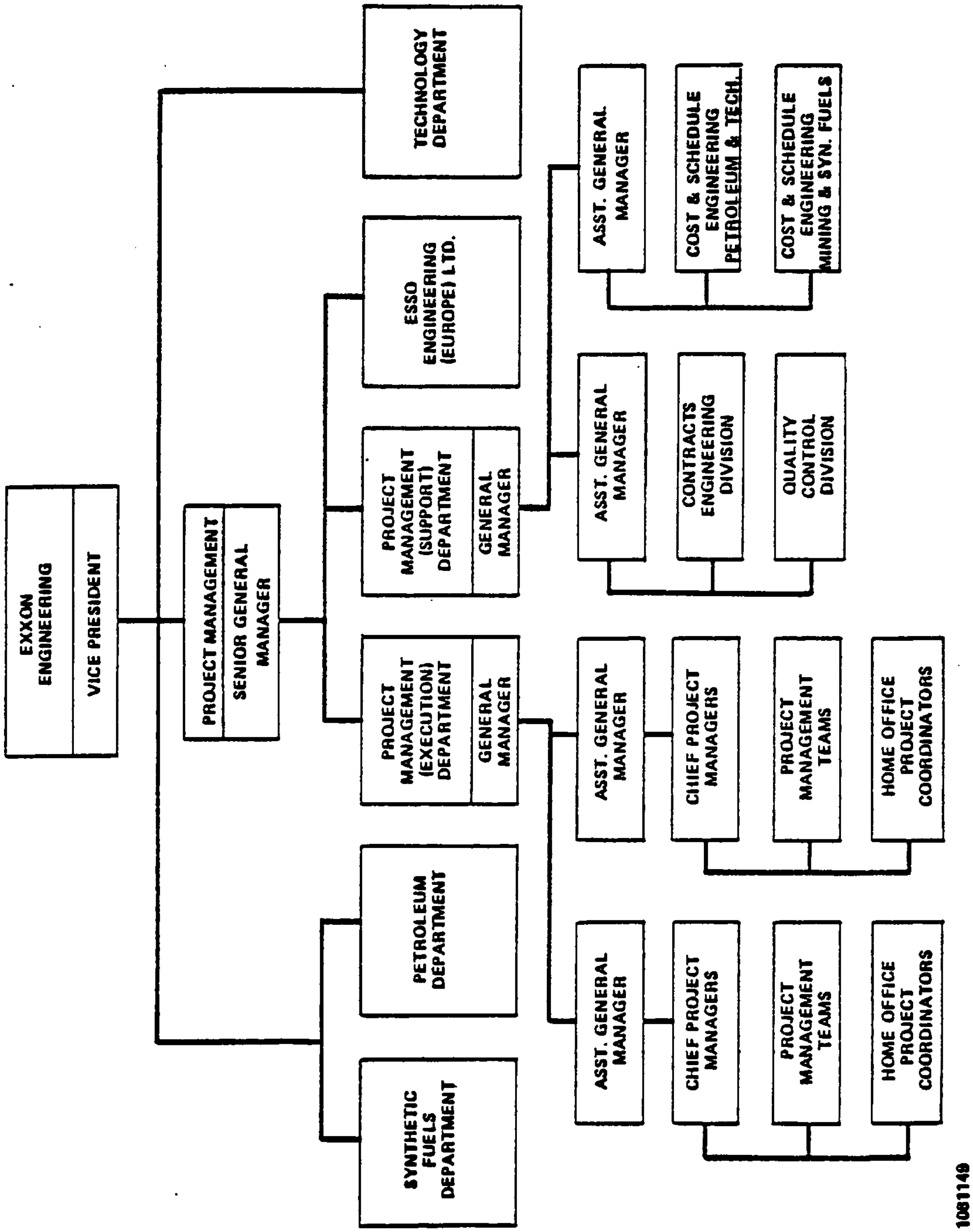
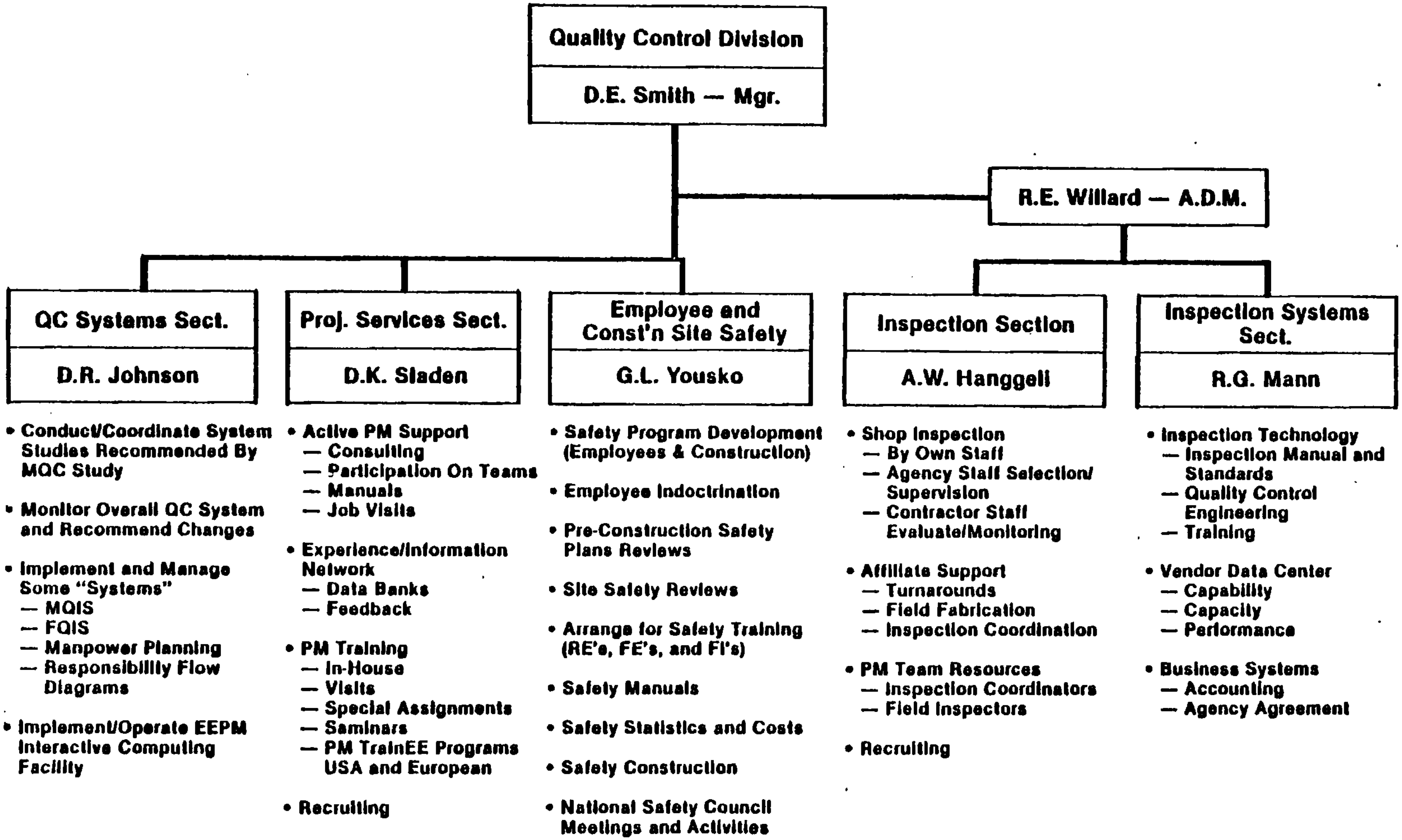

EXXON ENGINEERING
VICE PRESIDENT
PROJECT MANAGEMENT
SENIOR GENERAL MANAGER
TECHNOLOGY DEPARTMENT
ESSO ENGINEERING (EUROPE) LTD.
PROJECT MANAGEMENT (SUPPORT) DEPARTMENT
GENERAL MANAGER
PROJECT MANAGEMENT (EXECUTION) DEPARTMENT
GENERAL MANAGER
PETROLEUM DEPARTMENT
SYNTHETIC FUELS DEPARTMENT
ASST. GENERAL MANAGER
COST & SCHEDULE ENGINEERING PETROLEUM & TECH.
COST & SCHEDULE ENGINEERING MINING & SYN. FUELS
ASST. GENERAL MANAGER
CONTRACTS ENGINEERING DIVISION
QUALITY CONTROL DIVISION
ASST. GENERAL MANAGER
CHIEF PROJECT MANAGERS
PROJECT MANAGEMENT TEAMS
HOME OFFICE PROJECT COORDINATORS
ASST. GENERAL MANAGER
CHIEF PROJECT MANAGERS
PROJECT MANAGEMENT TEAMS
HOME OFFICE PROJECT COORDINATORS
1081149

FIGURE 3



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ATTACHMENT 1

PM SEMINAR GROUP PROBLEM

Problem: Changes

Given:

(1) Article 7, 17, 18 and 26 of the Principal Document

(2) Section 18 of the Coordination Procedure

(3) Ten letters addressed to you, the Owner's Project Manager, requesting changes.

Required:

(1) Classification of each letter according to whether the change requested represents:

a. Change within Job Scope

- Design/Process Development
- Estimate Adjustments
- Other . . . Engineering/Field Development and Minor Execution Changes

b. Revision of Scope or Basis
c. Extraordinary Random Event
d. Non-change

(2) Question: What do you and your Team consider the next logical steps in the processing of each classification? Please list.

(3) Assuming a change were to be processed for the addition of block and bypass valves at CV 106, list the personnel and steps, for both PM Team and Contractor, that would be involved in carrying the change through engineering.

(4) Question: Given the list of personnel and steps you developed, how do you and your Team rate the impact of this change on the Project — small or large?

(5) Question: What are the undesirable side effects of such changes? Please list four.

ARTICLE 7 - CHANGES

7.1 Discretionary Rights of Owner

7.1.1 OWNER shall have the right, without additional consent from CONTRACTOR, to (i) revise JOB SPECIFICATION, (ii) change elements of WORK already completed or being performed in accordance with JOB SPECIFICATION, or (iii) omit a part of WORK previously authorized, provided such revision or change is within the general scope of WORK specified in CONTRACT on CONTRACT date.

7.1.2 OWNER shall have the right, without additional consent from CONTRACTOR, to (i) make final decisions on the interpretation of JOB SPECIFICATION and on matters where JOB SPECIFICATION permits alternatives or is not specific, (ii) provide, designate or reject sources of supply for services, equipment, materials or supplies that JOB SPECIFICATION requires CONTRACTOR to provide, and (iii) require CONTRACTOR to provide engineering studies and cost estimates needed to ascertain the effects of a proposed JOB SPECIFICATION revision.

7.1.3 At OWNER's request, CONTRACTOR shall furnish under the provisions of CONTRACT additional services that are outside the general scope of WORK specified in CONTRACT on CONTRACT date, provided such additional services are within CONTRACTOR's personnel capacity at the time of OWNER's request.

7.1.4 OWNER shall have the right, without additional consent from CONTRACTOR, to adjust CONTRACT PRICE BUDGET and SCHEDULED COMPLETION DATE to correct errors or omissions in those items. OWNER shall issue a CHANGE ORDER with respect to such adjustments, but no FEE adjustment shall be allowed.

7.1.5 A CHANGE ORDER shall be issued with respect to the matters specified in 7.1.1, 7.1.2 and 7.1.3 if appropriate under the criteria of 7.3.1.

7.2 CONTRACTOR shall promptly comply with instructions, authorizations and notices given by OWNER with respect to WORK notwithstanding that a CHANGE ORDER has not been issued or that agreement has not been reached on the effects, if any, on CONTRACT PRICE BUDGET, SCHEDULED COMPLETION DATE or FEE.

7.3 Change Orders

7.3.1 Unless CONTRACT provides otherwise, OWNER shall issue a CHANGE ORDER when it revises JOB SPECIFICATION or elements of WORK already completed or being performed in accordance with JOB SPECIFICATION, requires additional services of CONTRACTOR or directs omission of part of WORK previously authorized, providing either of-the following CHANGE ORDER criteria is satisfied:

ARTICLE 7 (Continued)

a. CONTRACTOR's costs for performing WORK are affected thereby.

b. The time required for performing WORK is affected thereby.

7.3.2 If either of the foregoing criteria is satisfied, OWNER shall authorize CONTRACTOR to prepare and CONTRACTOR shall prepare an estimate of the effects on CONTRACT PRICE BUDGET, SCHEDULED COMPLETION DATE and/or FEE. After CONTRACTOR and OWNER agree on the reasonable effects, OWNER shall issue a CHANGE ORDER adjusting any or all of the three aforesaid items unless CONTRACT provides otherwise.

7.3.3 A CHANGE ORDER shall not be allowed when:

a. documents required to complete the initial issue of JOB SPECIFICATION are issued, unless they conflict with JOB SPECIFICATION at CONTRACT date,

b. minor design revisions are required to recently completed designs, or while the design work is in progress,

c. revisions in WORK already performed by CONTRACTOR are required to achieve compliance with JOB SPECIFICATION or to correct errors, omissions or work not in accordance with sound and generally accepted engineering and construction practices,

d. studies and cost estimates are required by OWNER to assure optimum design and/or construction,

e. the amounts of services, or the costs of materials, labor or services or the time required for performing WORK vary from those used in estimates made to establish CONTRACT PRICE BUDGET or SCHEDULED COMPLETION DATE, or

f. overtime work is performed or premiums or bonuses are paid by CONTRACTOR for earlier delivery of equipment or materials unless such action (i) is taken at OWNER's request and (ii) did not result, without being excusable under force majeure, from CONTRACTOR's having fallen behind the agreed upon detailed work schedule.

7.3.4 If, when considering a revision to JOB SPECIFICATION, OWNER authorizes studies or estimates pursuant to 7.1.2 but decides to not proceed with the revision, the CHANGE ORDER issued to cover the study or estimating effort shall not adjust SCHEDULED COMPLETION DATE.

ARTICLE 7 (Continued)

7.3.5 If CONTRACTOR believes that any instruction, interpretation, decision or other act or omission of OWNER, including unreasonable delays in providing approvals, authorizations, agreements or reviews, meets the criteria for a CHANGE ORDER pursuant to 7.3.1, CONTRACTOR shall promptly notify OWNER thereof. To the extent it reasonably agrees, OWNER shall issue a CHANGE ORDER pursuant to 7.3.2. No CHANGE ORDER shall be allowed if CONTRACTOR has proceeded with the work affected by said act or omission prior to notifying OWNER or if in OWNER's judgement:

a. said act affected CONTRACTOR's performance in a manner consistent with the requirements of CONTRACT or was necessitated by CONTRACTOR's failure to comply with a requirement of CONTRACT, or

b. CONTRACTOR's performance was adversely affected by another cause, including CONTRACTOR's fault or negligence.

7.3.6 In addition to the exercise by OWNER of its discretionary rights set forth in 7.1, certain circumstances are identified elsewhere in PRINCIPAL DOCUMENT (e.g. suspension, termination, force majeure) which specifically require OWNER to issue CHANGE ORDERS to document the effect of such circumstances on CONTRACT PRICE BUDGET, SCHEDULED COMPLETION DATE and/or FEE. When such a circumstance occurs, OWNER shall authorize CONTRACTOR to estimate the circumstance's effect on CONTRACT PRICE BUDGET, SCHEDULED COMPLETION DATE and/or FEE. After CONTRACTOR and OWNER agree on the reasonable effects of the circumstance on these items, OWNER shall issue a CHANGE ORDER adjusting any or all of the three aforesaid items unless CONTRACT provides otherwise.

7.3.7 CONTRACT PRICE BUDGET, SCHEDULED COMPLETION DATE and FEE shall be subject to adjustment only by CHANGE ORDERS, except as otherwise provided in 23.2. A CHANGE ORDER, when issued, shall be deemed to include the effect of the change in WORK or the circumstance covered therein on all previously authorized WORK.

END OF ARTICLE

ARTICLE 17 - SUSPENSION OF WORK

17.1 OWNER may suspend at any time and for any reason any part of WORK by giving at least twenty-four (24) hours notice to CONTRACTOR specifying the part of WORK to be suspended and the effective date of suspension. CONTRACTOR shall cease work on said part of WORK on the effective date of suspension, but shall continue to perform any unsuspended part of WORK. Suspension shall not limit or waive CONTRACTOR's responsibility pursuant to 2.1.4.

17.2 For the part of WORK suspended, only the costs of the following items shall be allowed as COSTS during the suspension period:

17.2.1 CONTRACTOR's home and branch office employees whose retention on WORK during the period of suspension has been authorized in advance by OWNER,

17.2.2 CONTRACTOR's field employees including those reasonably required by CONTRACTOR to fulfill its obligations under 2.1.4, and construction tools and equipment, provided their retention at WORK SITE during the period of suspension has been authorized in advance by OWNER, and

17.2.3 other items directly related to the suspended part of WORK, if authorized in advance by OWNER.

17.3 OWNER shall not be held liable for damages sustained by CONTRACTOR from suspension of any part of WORK.

17.4 OWNER may, at any time, authorize resumption of the suspended part of WORK by notifying CONTRACTOR of the part of WORK to be resumed and the effective date of suspension withdrawal. Work shall be promptly resumed by CONTRACTOR after receipt of such notice.

17.5 After withdrawal of suspension, OWNER shall issue a CHANGE ORDER. If the suspension was caused by or related to a force majeure occurrence, however, no adjustment to FEE shall be allowed. Furthermore, no CHANGE ORDER shall be allowed if part of WORK is suspended under 16.1 because of defects or deficiencies.

END OF ARTICLE

ARTICLE 18 - TERMINATION OF WORK

18.1 OWNER may terminate at any time and for any reason any part of WORK by giving ten (10) days notice to CONTRACTOR specifying the part of WORK to be terminated and the effective date of termination. CONTRACTOR shall cease work on said part of WORK on the effective date of termination, but shall continue to prosecute any unterminated part of WORK.

18.2 If, pursuant to Article 17, OWNER has suspended all remaining WORK and said suspension has been in effect for at least ninety (90) days, CONTRACTOR may notify OWNER of its intention to terminate all remaining WORK. CONTRACTOR may terminate all remaining WORK if within ten (10) days of OWNER's having received said notice, OWNER has not authorized resumption of WORK. This right of CONTRACTOR shall not apply to any suspension which occurred under 16.1 because of defects or deficiencies.

18.3 If part of WORK is terminated by reason of (i) defects or deficiencies, or (ii) CONTRACTOR's default in the performance of any material provision of CONTRACT (including failure to supply sufficient personnel or to perform WORK with diligence or to make prompt payments to its subcontractors, vendors and other suppliers of services, materials and equipment), or (iii) CONTRACTOR's becoming insolvent or making general assignment for the benefit of creditors or in any way becoming subject to a petition in bankruptcy or to the appointment of a trustee or receiver, OWNER may take possession of WORK and of all equipment, materials, supplies and construction tools and equipment, with reasonable compensation to CONTRACTOR therefor, and complete WORK.

18.4 If any part of WORK is terminated, OWNER with respect to such WORK shall reimburse CONTRACTOR only for COSTS incurred prior to the effective date of termination and for such additional amounts directly related to work performed by CONTRACTOR in terminating, providing said work was authorized in advance by OWNER. Also, FEE shall be reduced by an amount computed in accordance with 5.1 of Exhibit C and which reasonably represents the portion of FEE attributable to the part of WORK so terminated and not performed by CONTRACTOR. OWNER shall issue a CHANGE ORDER with respect to any termination.

18.5 Notwithstanding 18.4, if part of WORK is terminated under 16.1 because of defects or deficiencies, COSTS with respect to such WORK shall be reduced by estimates of the amounts set forth in 16.2.2, 16.2.3 and 16.2.4 that would not have been allowed as COSTS had CONTRACTOR been required to remedy the defect. If this amount is greater than the amount OWNER owes to CONTRACTOR, CONTRACTOR shall promptly refund the difference to OWNER.

18.6 If any part of WORK is terminated, with respect to such WORK CONTRACTOR shall execute and deliver to OWNER all documents and take all other necessary steps to vest in OWNER the rights and benefits of CONTRACTOR under existing agreements with vendors, renters of construction tools and equipment, and others.

18.7 OWNER shall not be liable for any damages sustained by CONTRACTOR from termination of any part of WORK.

END OF ARTICLE

ARTICLE 26 - FORCE MAJEURE

26.1 No delay or failure in performance by either party hereto shall constitute default hereunder or give rise to any claim for damages if, and to the extent, such delay or failure is caused by force majeure.

26.2 Force majeure is an occurrence beyond the control and without the fault or negligence of the party affected and which said party is unable to prevent or provide against by the exercise of reasonable diligence including, but not limited to: acts of God or the public enemy; expropriation or confiscation of facilities; changes in applicable LAW; war, rebellion, sabotage or riots, floods, unusually severe weather that could not reasonably have been anticipated; fires, explosions, or other catastrophies; strikes or any other concerted acts of workers; other similar occurrences.

26.3 The following are specifically excluded as force majeure occurrences unless (i) they were caused by force majeure occurrences of the type set forth in 26.2, and (ii) an acceptable alternate source of services, equipment or materials is unavailable.

26.3.1 Late performance by a subcontractor caused by a shortage of supervisors or labor, inefficiencies, or similar occurrences.

26.3.2 Late delivery of equipment or materials caused by congestion at a manufacturer's plant or elsewhere, an oversold condition of the market, inefficiencies, or similar occurrences.

26.4 If CONTRACTOR is delayed in performance of WORK by an occurrence it feels is force majeure, CONTRACTOR shall promptly notify OWNER, which if it agrees, shall then notify CONTRACTOR confirming the existence of force majeure. When the effects of said occurrence can be estimated, OWNER shall issue a CHANGE ORDER. No adjustment to FEE shall be allowed in such CHANGE ORDERS unless the force majeure occurrence was a change in applicable LAW affecting the requirements of JOB SPECIFICATION.

26.5 CONTRACTOR shall make reasonable efforts to minimize the effects of a force majeure occurrence on COSTS and COMPLETION DATE.

END OF ARTICLE

CHANGES IN WORK

1.0 Scope

This Section outlines the Owner's requirements for processing by the Contractor of change requests.

2.0 Prompt Handling of Changes

Revisions to the Job Specification should be expected during the normal course of engineering, procurement and construction. The Contractor shall respond promptly to requests for estimates of the effects, if any, that a proposed revision will have on the Contract Price Budget, Scheduled Completion Date and/or Fee. Contractor shall also respond promptly to requests for estimates of the effects of circumstances, identified in the Principal Document, for which Change Orders are allowable.

3.0 Procedures

3.1 The detailed procedures to be followed in the processing of change requests shall be agreed between the Owner and the Contractor. Those procedures should be compatible with the Contractor's normal methods, including use of standard forms, etc., provided these meet the requirements of this section and establish appropriate, control measures for handling changes. The procedures, which are to be documented by the Contractor, shall include details on the following:

3.1.1 Initiation of change requests.

3.1.2 Preparation of change proposals and timeliness thereof.

3.1.3 Formalizing and issuance of Change Orders.

3.1.4 Implementing Job Specification revisions.

3.2 To minimize the time required for estimating and to facilitate overall review, the Contractor shall use unit cost data which are consistent with the detailed control cost estimate. The use of such unit cost data will also insure that the quality and degree of detail in change proposal estimates parallel those in the estimates used to develop Contract Price Budget. Additionally, agreed percentages shall be used to reflect field labor overhead charges associated with increases/decreases in direct labor.

3.3 The Contractor shall respond to change requests by submitting a change proposal to the Owner within 7 calendar days of the initial request. The proposal shall include:

3.3.1 A brief description of revisions to the Job Specification and/or services involved, including appropriate identifying references.

3.3.2 Effects on Contract Price Budget and Fee, with cost subtotals reflecting estimated increases/decreases in direct material, direct labor, subcontracts, indirect field costs, home office and branch office costs, freight and duty, other costs (to be identified), fee, and cost of preparing the change proposal. The estimates shall be supported by accompanying backup data which clearly define how subtotals were developed.

3.3.3 Effect on Scheduled Completion Date, if any, with appropriate backup.

3.3.4 An indication of who initiated the change request (Owner, or Contractor) and reason therefor (safety, operability, Owner preference, investment return).

3.3.5 If applicable, a statement on the effect of the change on the Contractor's and Vendors' guarantees.

3.3.6 Effect, if any, on process or utility requirements.

3.4 If authorization to proceed with the revision has not been granted by the Owner, the change proposal shall include a statement defining the latest date such authorization can be given without further affecting the Scheduled Completion Date.

3.5 If the Contractor determines that the 7 calendar day schedule cannot be met, it shall promptly advise the Owner, state the reason for the delay and the date the change proposal will be available for review.

3.6 Contractor's project manager or his authorized representative shall countersign all Change Orders issued by Owner to document Contractor's receipt and agreement.

3.7 Contractor shall maintain a Change Order summary that is to include the following in tabular form: Change Order number, brief description of change, date change proposal is submitted to Owner, date approved or rejected, action on change (approval or rejection), effects on Contract Price Budget, Scheduled Completion Date and Fee, and remarks.

3.8 Each change request shall be assigned a Change Order number and be entered on the summary at the time it is requested. Subsequent entries shall be made at appropriate times to ensure that the summary is current. The Contractor shall issue the summary to the Owner monthly with its progress report and, otherwise, as requested by the Owner.

4.0 Work Authorization

4.1 Authorization by the Owner, for the Contractor to perform work associated with a change, will normally accompany the approved Change Order.

4.2 At the Owner's discretion, Owner may authorize the Contractor to perform all or part of the work associated with the change (in addition to preparation of a change proposal) at the time of issuing a change request.

4.3 If Contractor wishes to initiate a change request, it shall obtain Owner's approval before expending any engineering, cost estimating, scheduling or other effort in support of the request. The Owner if he approves, will issue a change request.

5.0 Distribution of Change Documents

Change proposals and Change Orders shall be distributed in accordance with Section 2, Schedule C.

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EXXON ENGINEERING
P.O. Box 101
Florham Park, N.J. 07932

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 1
October 14, Year 1
Subject: Nozzle Access Platform

Dear John:

During a recent plant inspection, John Smith suggested a platform should be installed below nozzle N-6 on tower T-101 to permit blinding the 10" flange at nozzle N-6. This would allow line Ala-1006 to be bled prior to the removal of pump P-106. Would you please proceed with the necessary steps to accomplish this installation.

Sincerely,

Harry B. Head
Startup Team Leader

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EXXON ENGINEERING
P.O. Box 101
Florham Park, N.J. 07932

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 2
October 20, Year 1
Subject: Block and Bypass
Valves at CV-106

Dear John:

The nature of the slurry in line A3b-3026 is such that it will erode the valve seat at CV-106 necessitating periodic repair. To prevent unit shutdown during repair of CV-106, I recommend the addition of block and bypass valves at CV-106. Would you issue the necessary documentation for this addition.

Sincerely,

Pete L. Jones
NPQC Instrument Specialist

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EXXON
P.O. Box 1000
Houston, Texas 77844

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 3
October 24, Year 1
Subject: Hydrogen Unit

Dear John:

As you know, during our recent meeting with you and your Process Follow-Up Engineers we concluded that it would be necessary to change the Hydrogen Unit from a single train per DS 81-103 to double trains, thus permitting continuous operation. Each train should be sized for sixty percent operational capacity and should be piped to permit simultaneous or separate operation. It is my understanding that you will pursue the ramifications of this alteration with the contractor.

Sincerely,

Bill T. Perkins
Exxon Project Executive

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WE CAN DO CONTRACTORS
2380 Borderline Avenue
Houston, Texas 77840

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 4
October 26, Year 1
Subject: Jobsite Shutdown

Dear John:

As you know, our jobsite was shut down yesterday, October 25, due to a walkout by the ironworkers. The picket line was honored and all work on the jobsite subsequently ceased. This serves to notify you that we are claiming Force Majeure under the terms of the contract. We will advise you of the cost, schedule and fee impact to the project as soon as our assessment is complete.

Sincerely,

Richard Roe
WE CAN DO CONTRACTORS
Project Manager

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WE CAN DO CONTRACTORS
2380 Borderline Avenue
Houston, Texas 77840

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 5
October 28, Year 1
Subject: Relocation of TI-201

Dear John:

Resulting from your review of our Process and Instrument Diagram, the location of TI-201 is to be changed so it will measure the temperature downstream of the mixpoint of branch Alc-3024. The relocation will cost nothing extra in piping or in other material and labor. However, we do request that a change be issued for the extra engineering hours expended.

Sincerely,

Richard Roe
WE CAN DO CONTRACTORS
Project Manager

Note: Upon re-examination of original Design Flow Plan No. 81-2 by the PM Team, TI-201 is shown to be located downstream of the mixpoint of branch Alc-3024.

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EXXON ENGINEERING
P.O. Box 101
Florham Park, N.J. 07932

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 6
October 29, Year 1
Subject: Start-up Line

Dear John:

To allow the start-up to progress as planned, I recommend installing a temporary start-up line between fuel gas line FG Ala-1234 and Furnace F-101. This line is to permit furnace dryout prior to start-up. Would you please proceed with the necessary steps to accomplish this installation.

Sincerely,

Harry B. Head
Start-up Team Leader

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EXXON
P.O. Box 1000
Houston, Texas 77844

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 7
October 31, Year 1
Subject: Additional Tank

Dear John:

As a result of changing market conditions, there exists a need for an additional tank of the same type as TK-102. This tank would not only double the capacity now indicated by DS 81-103, but would also increase our operational flexibility. Would you pursue the cost and schedule ramifications of this addition with the contractor.

Sincerely,

Bill T. Perkins
Exxon Project Executive

c70,187

EXXON ENGINEERING
P.O. Box 101
Florham Park, N.J. 07932

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 8
November 4, Year 1
Subject: New NPQC Safety Requirement

Dear John:

As part of the NPQC safety audit conducted last week, Greg Falls pointed out the new NPQC safety requirement that specifies the use of foam glass insulation in areas that are susceptible to fuel oil spillage. The following areas are effected by this requirement:

o Fuel Oil Strainers	PV-3	STR-119A, B
	G-02	STR-2A, B
o Bottom Pump Strainers	PV-3	STR-110A, B, C
o Front of SP-4 burners		
o Vicinity of fuel oil sample outlets		

Would you issue the necessary documentation to comply with this NPQC Safety Requirement.

Sincerely,

Joe Turnbuckle
NPQC Safety Engineer

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EXXON
P.O. Box 1000
Houston, Texas 77844

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 9
November 7, Year 1
Subject: Addition of Water Pump
and Water Heater

Dear John:

During a recent meeting with Plant Operations personnel, the addition of an industrial water pump to boost the water pressure to the chlorinators and the addition of an industrial water heater for the furnace preheater was requested. The additions will facilitate satisfactory unit maintenance/housekeeping. Would you please indicate to me the extent to which these additions will affect cost and schedule.

Sincerely,

Bill T. Perkins
Exxon Project Executive

a70,187

WE CAN DO CONTRACTORS
2380 Borderline Avenue
Houston, Texas 77840

Mr. John Q. Doe
Exxon Project Manager
c/o We Can Do Contractors
2380 Borderline Avenue
Houston, Texas 77840

PMT - 10
November 10, Year 1
Subject: Foundation for T-101

Dear John:

It has come to my attention that the foundation for the T-101 support structure was not included in the budget estimate. Would you issue a change to cover the cost of engineering and the construction of said foundation.

Sincerely,

Richard Roe
WE CAN DO CONTRACTORS
Project Manager

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Solution:

(1) Classification of Changes

Letter No.	Change Within Job Scope	Revision of Scope/Basis	Extraordinary Random Event	Non-Change
1	x			
2	x			
3		x		
4			x	
5				x
6	x			
7		x		
8	x			
9	x			
10	x			

(2) a. Change Within Job Scope

i. Test the Change — Owner and PM Team

A change should generally be considered only if the answer to either of the following questions is NO:

- As presently designed, can the plant be operated to meet the intent of the Project?

- As presently designed, does the plant satisfy Project safety requirements?

Practically, especially during early Project design development, changes can arise that do not fit these tests, e.g., changes to satisfy newly mandated government requirements, changes that overall will allow realization of substantial net savings, etc. Nevertheless, the routine of testing all changes against the questions above is worthwhile as a means of establishing early, and maintaining, Owner and PM Team cost-and-schedule sensitivity.

ii. Reject Changes that Fail the Tests — Owner and PM Team

iii. Forward Changes that Pass the Tests Through to the Contractor Via Change Requests — Owner's PM Team

Change Requests should in all cases instruct the Contractor to submit Change Proposals for subsequent Owner and PM Team review and further action.

iv. Review the Change Proposal — Owner and PM Team

The Contractor's Change Proposal should include a detailed cost estimate, an assessment of schedule impact, and effect on fee (when applicable). This information can be used by the Owner and PM Team to judge finally whether changes initially considered borderline, relative to operability and safety or other parameters, warrant the Contractor's forecasts of cost and schedule impacts.

v. Forward Changes that are Finally Accepted Through to the Contractor Via Change Orders — Owner's PM Team

The Change Order is the formal document that permits the Contractor to proceed with work execution. On occasion, and at the Owner's discretion, the Owner's PM Team may authorize the Contractor to perform all or part of the work at the time of issuing a Change Request. This practice, however, should be the exception rather than the rule.

(2) b. Revision of Scope or Basis

i. Assess the Change for Reappropriation Potential — Owner and PM Team

Scope/Basis changes are outside the contingency built into EE's Class II estimates. Such changes should generally be considered as items for Owner appropriation of additional funds.

ii. Forward the Change Through to the Contractor Via Change Request — Owner's PM Team

iii. Review the Contractor's Change Proposal — Owner and PM Team

iv. Dependent on Owner's Final Agreement and Instructions, Forward the Change Through to the Contractor Via Change Order — Owner's PM Team

(2) c. Extraordinary Random Event

i. Notify Contractor Per Pertinent Articles of Principal Document — Owner's PM Team

Extraordinary Random Events, like Scope/Basis changes, are outside the contingency built into EE's Class II Estimates. Force Majeure is the most common of this category of events and is usually handled by the PM Team. Force Majeure as defined in Article 26, is an occurrence beyond the control and without the fault or negligence of the party affected. When Force Majeure exists and when its effects can be estimated, the Owner issues a Change Order; however, no Fee adjustment is permitted unless the Force Majeure occurrence was a change in applicable law effecting the requirements of the Job Specification.

"Suspension of Work" per Article 17 and "Termination of Work" per Article 18 also fall into the category of Extraordinary Random Events. Both of these type of events are extremely rare and are usually business related. When they do occur, they are generally handled by the PM and a Contracts Engineer.

ii. <u>Issue Change Orders Per Pertinent Articles of Principal Document</u> — Owner's PM Team

(2) d. Non-Change

i. <u>Resolve Via Discussion Difference in Positions</u> — Owner's PM Team

The Contractor and the Owner's PM Team will on occasion take different sides on the issue of work constituting a change. Such issues should be resolved immediately, while details are fresh, and as a first step, verbally.

ii. <u>Confirm Resolution in Writing</u> — Owner's PM Team

(3) <u>Representative List of Personnel and Steps Involved In Change At CV-106</u>

- Owner's PM advises Contractor's PM and confirms by Change Request.
- Contractor's PM issues Change Memo to his organization
- Contractor's Cost Engineer estimates cost
- Contractor's Scheduler assesses schedule impact
- Contractor's PM submits Change Proposal to Owner's PM
- Owner's PM reviews Change Proposal and prepares and issues Change Order
- Contractor's Flow Sheet Draftsman makes change
- Contractor's Piping Draftsman makes change

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- Contractor's Flow Sheet Checker checks change
- Contractor's Piping Checker checks change
- Contractor's Materials Man takes off new material and enters it in Materials Summary
- Contractor's Purchaser orders new material
- Contractor's Prints Man revises original and issues copies for Construction
- Contractor's Materials Man revises Materials Summary Masters and issues copies for Construction

(4) Impact on Project of Change at CV-106

The change at CV-106 is small, but it has a disproportionally large impact on Project activities and people, as is evidenced by the list above. The larger, more complex the change, the greater this impact becomes. The Handout attached illustrates this.

(5) Some Undesirable Side Effects of Such Changes

- Schedule disruption
- Slow-down of job momentum
- Dampening of cost consciousness
- Diversion of effort from areas more critical

Prob. No. 2-HPW
GAB/WEW/ljb
October 22, 1981

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Instructor's Guide

Supplement for Revision of Scope or Basis

As a rule, Scope/Basis changes are outside the intent of the contingency built into the Class II Estimate; however, --

- When changes of this type are small and fit within the realm of normal Project funding

- And when the size of such changes practically do not justify formal appropriation of new funds

-- the Owner and PM may elect to absorb these within existing Project funding. Care must be exercised by the Owner's PM Team to guard against the cumulative effect of handling Scope & Basis changes in this manner. The Team PCE's Project Contingency Tracking Curves provide a mechanism for spotting problems in this regard.

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Handout:

(4) Impact on Project of Larger, More Complex Change

Example: Change main compression from single 100% machine to two 60% machines.

- Owner's Process Follow-up Engineer revises onsite design spec.
- Owner's Process Follow-up Engineer revises offsite design spec.
- Owner's PM Team develops Change List
- Owner's PM forwards Change List to Contractor requesting estimate and schedule impact
- Contractor's PM issues Change Memo to his organization
- Contractor's Cost Engineer estimates cost
- Contractor's Scheduler assesses schedule impact
- Contractor submits cost and scheduled impact of change to Owner's PM
- Owner's Project Cost Engineer reviews Contractor's estimate
- Owner's Project Schedule Engineer reviews schedule impact
- Owner's PM and Contractor's PM resolve any differences
- Owner's PM prepares and issues Change Order
- Contractor's Designer studies plot plan changes and makes recommendations to Owner's PM
- Owner's PM Team reviews proposed plot plan changes
- Contractor's Draftsman makes agreed revisions to plot plan
- Contractor's Plot Plan Checker checks revised plot plan
- Contractor's Print Man issues revised plot plan for construction
- Contractor's Machinery Engineer negotiates cancellation charges for large machine
- Contractor's Machinery Engineer prepares specs for 60% capacity machine

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- Contractor's Purchaser issues bid invitations
- Owner's PM approves payment of cancellation charges
- Vendors prepare and submit bids for two machines
- Contractor's Purchaser evaluates bids and recommends purchase
- Owner's NPQC Engineer reviews Vendors' proposals for technical adequacy
- Vendors price up any overlooked requirements
- Contractor's Cost Engineer adjusts bid evaluation
- Owner's PM approves purchase
- Contractor's Purchaser places order
- Contractor's Electrical Engineer specifies new electrical requirements and cancels any equipment and material needs made obsolete by the change

→ REPEAT COMPRESSOR STEPS FOR ELECTRICAL.

- Contractor's Instrument Engineer specifies new requirements and cancels items made obsolete by the change

→ REPEAT COMPRESSOR STEPS FOR INSTRUMENTATION.

- Contractor's Draftsman revise drawings to show the revisions made to underground piping, underground electrical, foundations, flow diagrams, above ground piping, electrical one line diagrams, wiring, grounding, and lighting, instrument piping, panel board, pipe supports, and compressor structure and building.
- Contractor's Materials Man takes off new material for bulk materials (i.e., piping, valves, rebar, etc.)
- Contractor's Materials Man disposes of obsolete bulk materials... cancels, places in refinery warehouse, sell, etc.

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ATTACHMENT 2

PM Seminar Individual Problem

Problem: Piping Layout

Given:

(1) Attached Proposed Piping Layout for part of the Powerformer Effluent Lines

A. Tube side piping at E-313
B. Shell side piping at E-116

(2) There are no vendors locally available that manufacture thick walled (Sch. 60), large bore (20" O.D.), alloy (2 1/4 Chrome) fittings intended for high pressure/temperature service.

(3) Existing equipment prevents piping directly from E-313 to E-116. The pipe must be supported by existing pipe racks A and B as shown on the proposed piping layout.

(4) No piping model will be constructed for this project.

(5) Fitting costs - material cost only - are as follows:

- 20" O.D. 90° Elbows - at $3630.00 each
- 20" O.D. 45° Elbows - at $1815.00 each*

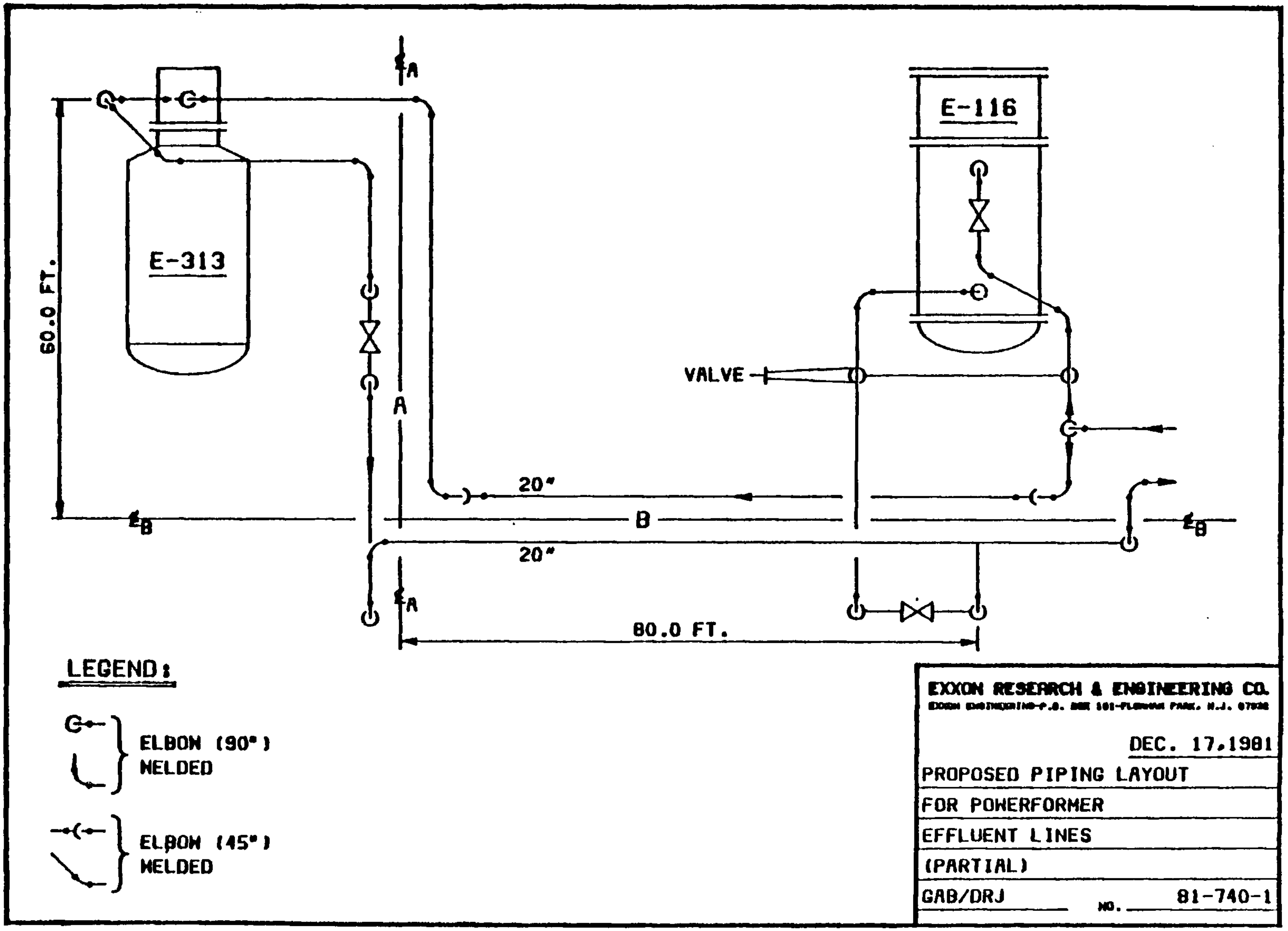
* Two 45° Elbows can be made by cutting one 90° Elbow into two equal pieces. Manufactured 45° Elbows cost considerably more than 90° Elbows due to the relatively small demand for 45° Elbows.

Required:

As a Project Engineer, appraisal of the contractor's piping layouts for economy and sharpness is one of your responsibilities in the cost area. In that respect:

A. Review the attached Proposed Piping Layout. Sketch an improved piping layout that would demonstrate to the contractor the possibility of reducing the number of fittings currently required.

B. Using the cost data given, calculate the cost savings realized from your improvements.


E-313
E-116
60.0 FT.
A
B
20"
20"
VALVE
80.0 FT.
LEGEND:
ELBOW (90°) WELDED
ELBOW (45°) WELDED
EXXON RESEARCH & ENGINEERING CO.
DEC. 17, 1981
PROPOSED PIPING LAYOUT
FOR POWERFORMER
EFFLUENT LINES
(PARTIAL)
GAB/DRJ
NO. 81-740-1

A1740A

Solution:

A. Improved Piping Layout - See Attached

The attached represents one approach to improving the proposed piping layout. It considers only the configuration of the pipe and the number of fittngs involved. Some other areas that would also normally be appraised are:

- Heat expansion and flexibility
- Existing equipment and pipe racks
- Vessel supports
- Space Limitations
- Maintenance and operability

B. Cost Savings from Improvements

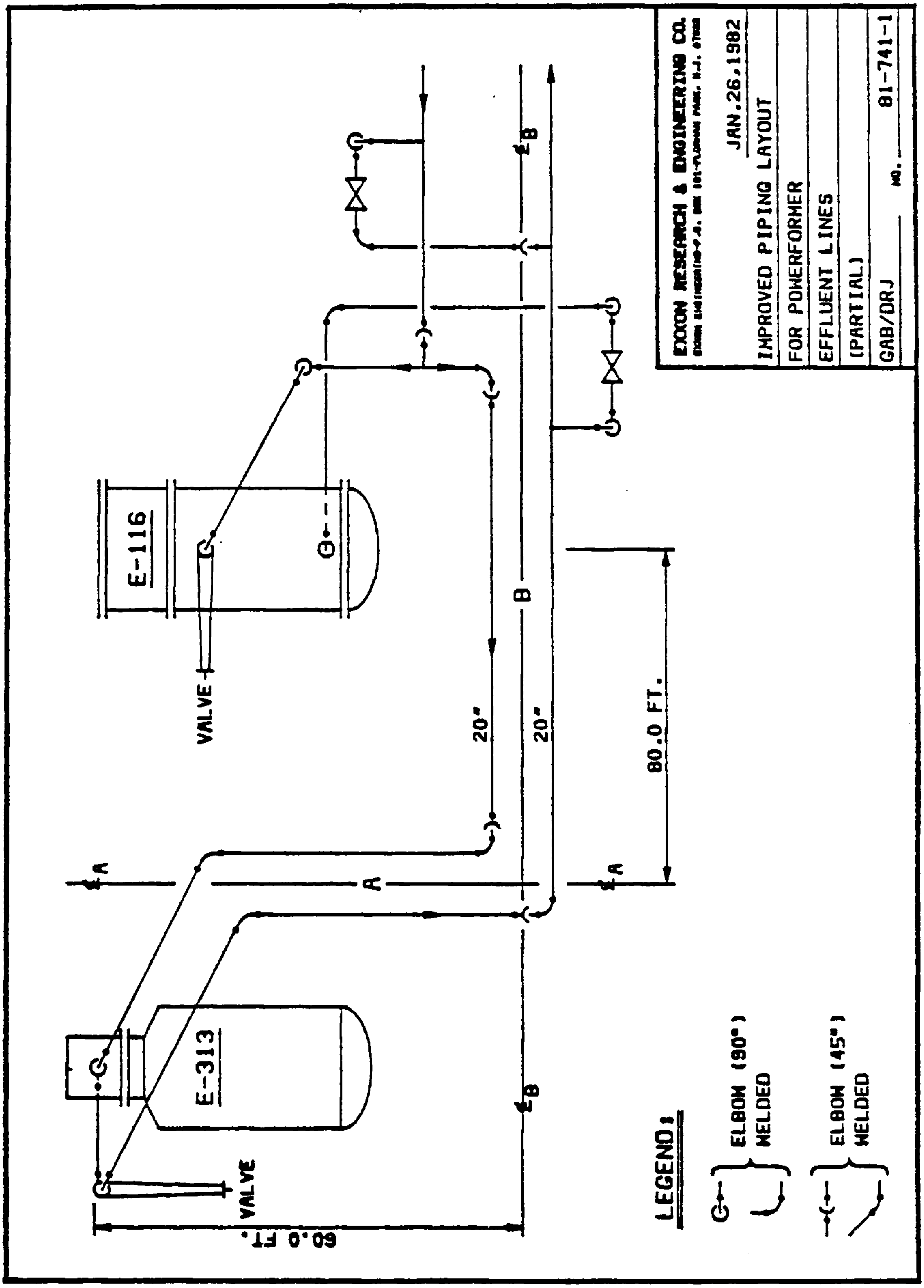
	90° Elbow	45° Elbow
Proposed Piping Layout	28	5
Improved Piping Layout	19	7
Difference	-9	+2

or Equivalent Savings of 8 - 20" O.D., 90° Elbows

at $3630.00* each = $29,040

* 4th Quarter 1981 price for 20" O.D., Sch. 60, 2 1/4 Chrome, Chrome/Carbon Alloy

Problem Number 23 JC-JFH
GAB:gmk
December 10, 1981


EXXON RESEARCH & ENGINEERING CO.
JAN.26,1982
IMPROVED PIPING LAYOUT
FOR POWERFORMER
EFFLUENT LINES
(PARTIAL)
GAB/DRJ
NO. 81-741-1
E-116
E-313
VALVE
VALVE
A
B
20"
20"
80.0 FT.
60.0 FT.
LEGEND:
ELBOW (90°)
WELDED
ELBOW (45°)
WELDED

VITA

George A. Bridges was born on December 13, 1956 in Gainesville, Florida. The author's parents are George Garland and Dorothy Jean Bridges of P. O. Box 606, Jasper, Texas 75951. The author's permanent mailing address is the same as his parents' address.

The author graduated from Jasper High School in Jasper, Texas in 1975. The author received a Bachelor of Science in Civil Engineering from Texas A&M University at College Station, Texas in 1979. With emphasis on Construction Management, the author received a Master of Engineering degree in Civil Engineering from Texas A&M University in 1980.

The author's work experience prior to the internship resides in various sections of the construction industry with positions in both a specialty subcontracting organization and the Texas Department of Highways and Public Transportation. Additionally, the author served two years as a Teaching Assistant at Texas A&M University.

The author is a certified Engineer in Training in the State of Texas and expects to be registered by early 1984.