**PROJECT ADMINISTRATION DATA**

**OCA contact:** Kathleen R. Ehlinger  
**Sponsor technical contact**  
**UNIVERSITY OF TEXAS AT AUSTIN CONSTRUCTION INDUSTRY INSTITUTE**  
**Address:** 3208 RED RIVER ST., SUITE #300  
**City and Zip:** AUSTIN, TEXAS 78705-2650  
**Security class (U,C,S,TS):** U  
**Defense priority rating:** NA  
**Equipment title vests with:** Sponsor  
**ONR resident rep. is ACO (Y/N):** N  
**NA supplemental sheet**  

**Administrative comments:**  
**ISSUED TO EXTEND TERMINATION DATE FROM 8/31/91 TO 12/31/91.**
GEORGIA INSTITUTE OF TECHNOLOGY  
OFFICE OF CONTRACT ADMINISTRATION  

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 04/08/92

Project No. E-20-682

Center No. 10/24-6-R7001-0A0

Project Director RIGGS L S

School/Lab CIVIL ENGR

Sponsor UNIVERSITY OF TEXAS AT AUSTIN/AUSTIN,TX

Contract/Grant No. DTD 900601

Contract Entity GTRC

Prime Contract No.

Title MANAGING RETROFIT PROJECTS

Effective Completion Date 911231 (Performance) 911231 (Reports)

Closeout Actions Required:  

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Comments

Subproject Under Main Project No.  

Continues Project No.  

Distribution Required:

- Project Director
- Administrative Network Representative
- GTRI Accounting/Grants and Contracts
- Procurement/Supply Services
- Research Property Management
- Research Security Services
- Reports Coordinator (OCA)
- GTRC
- Project File
- Other

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MANAGING RETROFIT PROJECTS

by

Victor E. Sanvido¹
and
Leland S. Riggs

A Final Report Submitted to the Construction Industry Institute
Department of Civil Engineering
The University of Texas at Austin

August, 1991

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We also thank the people and companies on the 16 projects visited that made this project successful. Finally we thank the members of CII for funding this project.
EXECUTIVE SUMMARY

Retrofit projects are becoming increasingly more important as owners face economic and environmental constraints to new or grass roots projects. There are many justifications for retrofit projects which might include: expanding plant capacity, incorporating a new technology, reducing cost, increasing quality, meeting environmental requirements, and enhancing safety.

The retrofit project can also be defined many ways. For the sake of uniformity and to place appropriate bounds on our research, we define the retrofit project as follows.

"A retrofit project is the modification or conversion (not a complete replacement) of an existing process, facility, or structure. Such modification may involve additions, deletions, rearrangements or not-in-kind replacements of one or more parts of the facility. Changes may alter the kind, quantity, cost or quality of the products or services being produced by the facility."

As the definition implies, the retrofit project is different from the grass roots project. The difference is mainly reflected in the constraints of the retrofit project. The Task Force identified what they felt were four main constraints. Certainly, grass roots projects also have many of these same constraints but, in most retrofit projects, these constraints are much more intense. These were information, time, space, and environment.

Information is constrained in that existing data is often limited. Project scope can be unclear, the condition of existing equipment may be uncertain, and as-built drawings may not be up-to-date.

Time is constrained because many retrofit projects must be completed during a very narrow window of opportunity during a plant shut down. Additional constraints on time might include acute pressure to bring a product to market within a given season or to beat the competition.
Space is constrained on nearly all retrofit projects. By its very definition of working within an existing facility, the retrofit project competes for space. Space congestion introduces problems of laydown areas, access to the facility for workers, rigging, and work sequencing of equipment.

Environment is constrained by temperature extremes, working with hazardous or toxic materials, noise, and vibration.

Purpose, Scope, and Methods of this Research
The purpose of our research was to compile a list of effective management, engineering, and construction techniques used in retrofit projects. We also wanted to identify those factors related to both successful and unsuccessful retrofit projects.

The scope of our research includes power, process, industrial, and commercial projects. The researchers visited 16 separate projects whose value ranged from less than one million to over one hundred million dollars. Project time ranged from less than one month to just under three years.

Our research methods included an initial literature search to see what had been published on retrofit projects. The literature search produced very little written information. This confirmed, to some extent, our belief that the research was justified. The bibliography at the end of this report lists the documents relevant to our research.

Additionally, we developed a data collection package to insure a degree of uniformity in the research. The package included instruction to the participants at each of the sites we visited as well as a questionnaire to guide the data collection session. The initial questionnaire was a prototype which we revised after our experience on the first five projects. Appendix B4 and B5 include the full text of the questionnaires.

Task Force members proposed a total of 33 projects designed to give us a broad base in the type of project. From the list of 33 projects, we selected 16 to visit. These 16 projects were then grouped geographically for more efficient access by the researchers. Appendix C2 contains more detail on the projects visited.
During site visits the researchers were first briefed by the project participants. This briefing was usually followed by a site visit to orient the researchers to the project. In the data collection phase, the researchers attempted to talk with representatives from the owner, the designer, and the constructor. During this discussion, the questionnaire described above was used to assist the researchers collecting the data. Generally, the researchers spent on the average, one day at each retrofit site. Chapter 2 includes more detail on research methods.

Findings

Although our initial effort was to focus on retrofit techniques, it quickly became apparent that questionnaire responses related more to success factors than to techniques. Of these success factors, our major finding was that the right project team was the most important factor on the outcome of the project. The right team includes more than just appropriate experience and skills. It also includes a team with the right chemistry and attitudes, a team that is flexible and responds quickly and decisively to changes, and to the unplanned events typical of such projects. It is a team that is formed early and remains together until the end of the project.

There is sometimes a tendency to assign inexperienced people to retrofit projects in a well meaning effort to give them experience. It would appear that this effort is misplaced given the potential negative impact on the project. If inexperienced people must be assigned to retrofit projects, it is perhaps better to assign them initially in subordinate rather than decision making roles.

There are strong feelings that the people who comprise an effective retrofit project team must have an aptitude for the fast paced, hands on demands of retrofit work. Good retrofit project people are not necessarily good grass roots project people.

Other success factors included contract incentives, partnering arrangements, special procurement and preplanning strategies, and high level management support. It is interesting to note that management of time, space, and the working environment were not given as major factors contributing to success or failure of the project. Details of these success factors along with important techniques are found in Chapter 3.
Conclusions
This research is considered to be a first step in defining a body of knowledge unique to retrofit projects. As such the research is exploratory in nature. The results suggest to us that the retrofit project is worthy of additional research. Additional research might focus on how to form and nurture the right project team.

Further, research might focus on ways to validate the success factors identified in this research. An objective model of the retrofit process might be developed. This model might then be used to identify differences from grass roots projects. Techniques could be developed to manage these differences.

Since we found little in the literature on retrofit techniques and respondents in our research offered limited information on techniques, perhaps an action team could produce an educational package on techniques. Additionally, an action team or task force might be formed to study the costs and benefits of selected retrofit techniques. Alternatively, a pilot project could be identified and selected retrofit techniques could be monitored during the entire life of the retrofit project. Particularly important here could be preplanning techniques.

As the retrofit project becomes more important, it seems prudent to explore ways to make the process as efficient as possible. This research is seen as a first step in this exploration.
CHAPTER 1 - SCOPE OF WORK

INTRODUCTION

The last twenty years has seen a decrease in large grass roots construction projects and an increase in retrofit projects. This trend is expected to continue. While there seems to be a large body of information on grass roots projects, a literature search turned up very little in the way of usable information about retrofit projects. This report therefore represents a first step in developing and documenting a body of knowledge on retrofit projects.

The retrofit project is different from the grass roots project in many ways. By definition, the retrofit project involves an existing facility. Working in an existing facility, in turn, imposes constraints on the owners, operators, designers, and constructors. Briefly, these constraints include insufficient information, physical limitations, and operational constraints related to the existing facility. All projects have constraints, but the retrofit project is unique in that the degrees of freedom available to all parties are limited. Appropriate management and technical methodologies might solve, mitigate, or circumvent problems caused by these constraints and thus reduce project costs, shorten schedules, and achieve other project objectives.

This report describes the factors that are critical to the success of a retrofit project. It also lists management, engineering and construction techniques that can be effective in avoiding, mitigating or controlling problems caused by retrofit project constraints. In several cases the report also includes specific examples of these techniques, and how they contributed to the success or failure of specific retrofit projects. The report tabulates the lessons learned by professionals who have applied these techniques to retrofit projects.

RETROFIT PROJECT DEFINITION

The following definition was developed by the Retrofit Projects Task Force of CII:

"A retrofit project is the modification or conversion (not a complete replacement) of an existing process, facility or structure. Such modification may involve additions, deletions, rearrangements or not-in-kind replacement
OBJECTIVE

The objective of this research is to identify the critical management, engineering, and construction factors that will facilitate successful execution of retrofit projects. This research also compiles methods and techniques used by owners, designers and constructors in planning and executing retrofit projects. It cannot be overemphasized that the study focused on the constraints that make retrofit projects so much more difficult than new construction projects. We did not initially devote our resources to rediscovering the basic principles of project management that apply to all jobs, both grass roots and retrofit, neither did we ignore them when critical to success.

SCOPE

The scope of the research includes power, chemical, petrochemical, industrial, and commercial building projects. The projects were selected to provide a broad and varied population. They included both "successful" and "unsuccessful" projects since both can be valuable teachers. The projects varied in size from tens of thousands of dollars to over one hundred million dollars. They represent geographic locations from east to west and north to south in the United States. Our research covers all phases of a given project, namely, managing, planning, designing, constructing and operating facilities.

RESEARCH APPROACH

Initially the task force defined the term "retrofit project" and brainstormed a list of project management and technical issues that affect problems particular to retrofit projects. The results of this brainstorming effort formed the framework for the research. It should be noted that the task force consisted of twelve members of CII who had experience in the retrofit area.

The initial focus was on the planning phase, and the task force members were surveyed to determine the key issues involved in the planning phase of the project. Based on this input, a questionnaire was developed to guide data collection. Once the questionnaire was completed, representative retrofit projects were selected from a pool of candidate projects submitted by the
task force. These projects were then divided into five geographic groups to facilitate data collection by the researchers.

The researchers visited each selected project and gathered information from owners, engineers, and contractors. Using the framework developed by the task force, each party gave brief presentations describing their techniques for better managing retrofit projects. Following these presentations, the investigators sought additional detail and clarification of matters of special significance from each participant individually.

Once the data was reduced, it was presented to the task force for comments. The results were organized by topic and consolidated. An examination of the data revealed several factors which seemed to contribute to the success or failure of retrofit projects. These factors are presented later in this report.

**READER'S GUIDE**

Chapter One orients the reader to the study. Chapter Two focuses on the research methods. The development of the questionnaire, the selection of sites, the data collection on the sites, and the data analysis are described.

Chapter Three analyzes the results of the survey sorted for each question. Based on this survey we compiled a list of Critical Success Factors and a list of Success Factors. Following this, the data is then analyzed by topic, and techniques used to successfully manage retrofit projects are listed. A listing of desired tools to better manage these projects is presented.

Chapter Four concludes the study and highlights the lessons learned. Based on this exploratory survey, several specific areas of research are identified. These could provide a stepping stone into a research area that seems to be critical to the U.S. Construction Industry. The Appendices provide examples of the research methods and tools to assist future researchers.
CHAPTER 2 - RESEARCH METHODS

RELATIONSHIP OF REPORT TO OTHER WORK

One of the first items of business considered by the Task Force was an attempt to place manageable bounds around the retrofit problem. This included a brainstorming session focusing on the definition of a retrofit project, types of facilities to be studied, retrofit characteristics, cost issues, advantages/disadvantages of retrofit work, and contract types best suited to the retrofit project. The brainstorming session provided a framework for discussion at future meetings. Additionally, it was decided that a computerized literature search should be helpful to determine the extent of published work on retrofit projects.

The computer search produced ninety-one citations using the following key words: retrofit, renovation, modernization, remodeling, revamp, and rehabilitation. Abstracts of the ninety-one citations were presented to the task force, and the list was pared down to twelve articles felt to be relevant to our job of identifying retrofit techniques. The other articles dealt with retrofit aspects such as engineering, economics, materials, technologies, and feasibility studies which were not within the scope of the task force's charter. Of the twelve articles identified, only eight were applicable. These articles are included in a bibliography in Appendix A.

The small number of useable articles confirmed our initial belief that there was little in the way of published material documenting retrofit management techniques. Beyond the literature search, seven presentations by individual task force member companies were an valuable source of information. These presentations included case studies of actual retrofit projects illustrating issues on which the task force was attempting to focus.

The task force also considered several other documents which are worthy of note. One was a document on design scope published by the CII Cost/Schedule Controls Task Force. This document was pertinent because inadequate scope control is believed to be a notorious contributor to cost overruns on many retrofit projects. Another document was a study by the Rand Corporation entitled "Understanding Cost Growth and Performance Shortfall in Pioneer Projects." This study was an effort to understand the causes for inaccurate cost estimates and performance difficulties in first-of-a-kind process plants. These two documents are also included in the bibliography. Finally, a preliminary chapter by the CII Small Projects Action
Team covering the retrofit project provided an excellent survey of techniques suggested by retro fit project managers. This document was developed in parallel with and somewhat late into our project. We were gratified to learn that this action team had also identified some of the same techniques we had concluded were important.

DATA COLLECTION PACKAGE

The researchers developed a data collection package to assist with data collection. The information package is made up of four documents. The first, the task force letter (Appendix B1), explains the purpose of the visit and orients the project players to the study. Appendix B2 is a series of documents that define the key issues and purpose of the study. Appendix B3 includes the guidelines describing the desired conduct of the study. Appendix B4 is the initial questionnaire and Appendix B5 is the final questionnaire used in the study. Appendix B6 is the Data Confidentiality Policy adopted for this study.

DEVELOPING THE QUESTIONNAIRE

As noted earlier, the researchers used task force meetings to brainstorm and develop the key topics to be considered when planning retrofit projects. The key topics were listed initially as: People, Knowledge, Materials, Technology, Space, Time, and Money. Based on this input, the researchers surveyed task force members to define the details and key issues considered in each topic when planning retrofit projects.

Initial Information Categories
After analyzing the data from task force members, the researchers decided to focus on: Information, Time, Space, and Environmental as the four key retrofit project constraints. Details of each of the four categories follow.

Information
- Existing Information such as: P & IDs; Underground & Foundation; and Electrical Documents.
- Used Equipment Condition, Capacity, and Manuals.
- Materials of Construction.
- Design/ Construction Codes and Standards.
- Structural Strength/ Integrity.
- Utilities.
Time
- Shut-Down Duration.
- Shut-Down Timing: Scheduled, and Unscheduled.
- Division between Construction and Maintenance Activities.

Space
- Construction Space including Offices, Parking, and Laydown Areas.
- Accessibility to Existing Facilities for People, Rigging, and Scaffolding.
- Division of Space for Construction and Maintenance Activities.
- Sharing Common Space.
- "Musical Chairs," e.g., the successive removal, replacement, or rearrangement of equipment.

Environmental
- Temperature.
- Process Materials including Flammables and Toxics.
- Noise.
- Vibration.
- Product Contamination.

Initial Questionnaire
The initial questionnaire (see Appendix B4) consisted of seven sections designed to draw out information from retrofit project participants. The first section, Project Performance gave an orientation to the project and its success. Sections Two through Five focused on the critical categories of information, time, space, and working environment defined above. Section Six focused on personnel management. Section Seven included other data found by the researchers. This questionnaire was used on the first five projects. Based on the experience gained it was then modified for the remaining projects.

Final Questionnaire
The final questionnaire is included in Appendix B5. The following changes were made:
1. A section orienting the researchers to the product produced and the associated processes was developed.
2. A section was added to investigate the planning activities on the project (Section 2).
3. A final section was included to elicit lessons learned on the project (Section 8). In the final section, researchers asked questions such as:

- Compare your first retrofit project to this one. What has changed in your approach?
- What were key lessons learned as a result of this project?
- What would you do different on your next job?
- Is there any tool or guideline that would be useful to you in executing retrofit projects?

The final questionnaire categories were: Product and Process Orientation; Project Performance; Planning; Information Management; Time Management; Space Management; Management of the Working Environment; Personnel Management; and Other.

SELECTING PROJECTS

In order to select projects to be studied on this research project, the task force developed a Project Profile Sheet (See Appendix C1). The Project Profile Sheet sought important project data such as: project size; industry sector; project duration; product produced; project justification; etc. These forms were completed by each task force member for each project they proposed for study.

A total of 33 projects was proposed. Projects were selected to represent a diverse sample. Additional visits to two building projects and one industrial site were eventually included. In total the researchers visited 16 projects comprising: nine process; four commercial/high tech buildings; two power; and one industrial plant. Appendix C2 provides data on the projects visited.

DATA COLLECTION PROCEDURE

In order to test the data collection methods, the researchers visited five projects. Each site visit was slightly different in procedure and had different members of the project team present. The first two projects were similar and involved the same owner but different engineering and construction contractors. Initially one construction contractor introduced us to his staff and took us on an extensive site tour. The contractor then scheduled a group meeting. Those present were: the project managers from both contractors, one owner's project manager, and an owner's contracting officer. No engineering people were present - hence their perspective was
not included. We discussed the project individually with the three parties. We spoke for one
hour with the owner's project manager, 30 minutes with one contractor (the owner was
present) and 90 minutes with the other. The presence of the owner seemed to hinder the
candidness of the first contractor. Nonetheless, we feel sufficient information was gathered.

On projects 3 and 4, the team completed the questionnaire ahead of time and faxed it to the
researchers. We met for an hour where the project team provided general discussion of the
products being manufactured, and the history of the project. The owner's project manager as
well as the engineering and construction contractors for both projects were present at the
meeting. After an extensive job tour, the project team as a whole reviewed their project
responses for each project. The researchers did not individually question the participants for
their perspectives, hence some responses may have been restricted. Again, sufficient
information was provided to the researchers.

The whole project team and several owner's personnel were assembled for project 5. The
project manager reviewed the products and some project history. The responses to the
questionnaire were covered in detail, before we were taken on a site tour. In this visit no time
was available for individual one-on-one questions.

Revised Procedure
Based on the different experiences on data collection at these five site visits, the researchers
selected the following data collection procedures for the remaining projects.

The task force member informed the owner of the visit and the owner set up the meeting.
Upon arriving at the site the general meeting took place. All project participants described job
history, roles of players, project facts, and progress to date. Following this meeting, the
project site was toured. Written solutions to the questionnaire were then presented to the
researchers, and individual participant meetings were scheduled to clarify the responses to the
questionnaire. Approximately 30 minutes was scheduled with the owner, engineer, and
construction contractor for one-on-one questions. This procedure provided the optimum
approach to collect data and did not require modification for the remaining eleven projects
visited.
CHAPTER 3 - RESULTS OF SURVEY

INTRODUCTION

This chapter presents the results of the survey in two ways. First, a list of factors cited by project personnel as critical to project success are listed as Critical Success Factors. Other factors less critical to success are labeled Significant Success Factors. Secondly a list of techniques used by various project teams to manage retrofit projects are included. These are called Retrofit Project Management Techniques.

In order to arrive at these two groupings, the data collected in the survey had to be sorted by question and then grouped by topic. This was necessary because some questions yielded data supporting several topics. Initially, the data collected on each project was reduced to key phrases that represented the response to a question or condition observed. For example, the phrase “Cohesive team with chemistry” describes a project team that behaved in a cohesive, unified manner and exhibited a strong chemistry or ability to work together. This data was then summarized by question (see Appendix E) to yield Success Factors and then by topic (see Appendix F) to yield techniques.

ANALYSIS OF DATA SORTED BY QUESTION

Appendix E presents the site data collected by each question on the questionnaire. In some cases similar responses came from more than one project. In several cases when asked a question, the respondents provided data that applied to several topics. Their full response was stored in the section allotted to that question.

When reviewing the data in Appendix E, one must separate the sections titled Project Performance; Other; and Key Lessons Learned (Sections 1, 8 and 9) from the others. These three sections were designed to solicit the key factors that contributed to success or failure of a project. Section 10, which discussed the desired retrofit tools, highlights deficiencies causing failure on projects. These responses are used as a cross check to support the findings in sections 1, 8, and 9.

It is important to note that the questionnaire allowed the respondents to reply in a free format, hence the answers were not biased. The remaining six sections (2 to 7 in Appendix E) requested
evidence of techniques used by the project team in those areas. Respondents did not state whether these issues were critical to the success of the project. For these reasons, the data in sections 1, 8, 9, and 10 should be reviewed to help the reader visually assess the importance of the success factors.

FACTORS CAUSING SUCCESS ON PROJECTS

When analyzing the first group of factors that contributed to success of the project, one factor was found to be critical to nearly all projects. The Project Team was the single most dominant factor that influenced the outcome of a project. Several other secondary level factors were identified. The factors included Contracting, Procurement, Resources, Support, Preplanning, Communications, and Information. Some of these factors support the question categories, e.g., preplanning, while others are new, e.g., contracting. It is interesting to note that management of time, space, and working environment were not cited as causes of the success of a project.

Critical Success Factors

The factors most critical to the success on retrofit projects all pertain to the project team. These factors are not unique to retrofit projects, but perhaps retrofit projects are less tolerant of team weaknesses. These attributes are:

1. The project team is cohesive and has developed good chemistry between the players.
2. The team is flexible and can respond to changes but is decisive.
3. The team is formed early in the project life and works together until the end.

In addition the team members exhibit the following characteristics:

1. The owner, engineer, constructor and operator provide early input as a team.
2. The team members have experience in retrofit projects, and usually have worked in the given plant.
3. The owner has a decisive project champion who wants the project to succeed.
4. Design and construction contractors are located on the site in proximity to each other for the project duration.
5. Operations provide a single point of contact and dedicated operator support.
Significant Success Factors
Other factors that caused success were supported to a lesser degree by the data, thus they are termed significant success factors. They are found when the following conditions on a project are met:
1. Contract incentives are used to improve the performance of the designer, contractor and labor.
2. Actual and de facto partnering agreements with engineers and constructors are used in appropriate projects.
3. Special procurement procedures e.g., double buying key material, are effectively applied in specific cases.
4. The owner manages and understands the scope of work.
5. Contractor personnel have prior knowledge of the plant.
6. Preplanning is used to help the team to understand and develop common goals.
7. There is constant, open communications among the team members.
8. There is an adequate supply of resources and top management support for the project.

While these factors were not unanimously supported for all projects, we believe that this exploratory study provides excellent support for these factors. There were also many other techniques that were used on the projects visited, but project players could not link their use to project success.

Desired Retrofit Tools
Responses from personnel on several projects indicated a desire for tools to help them better manage retrofit projects. These retrofit tools highlight deficiencies in several areas and support the factors listed above. The retrofit tools can be grouped into the following four categories:
1. Tools to facilitate better input by the client and feedback from the team (5 instances).
2. Teambuilding techniques (2 instances).
4. Better tools to predict cost/schedule in design (1 instance).

ANALYSIS OF DATA SORTED BY TOPIC

As mentioned earlier, respondents sometimes supplied data for several topics when answering a given question. The data was then resorted by topic (See Appendix F). These topics were selected to divide the data into sizeable portions of similar importance for description and analysis. Each topic has a listing of the responses or evidence found, and the project numbers on which it was found. Negative instances which hindered project success appear in bold face in Appendix F. In
several cases more than one instance of a topic was found. This is indicated by multiple responses for the same project in that section.

The tables that follow in this chapter isolate the data by topic and present weightings for the data. The two types of weightings shown are: number of occurrences, and number of projects from which the response came. Obviously if more than one indicator on a project was found, the evidence on that project would be more significant than if only one instance was evident. In addition to the weightings, the tables indicate whether the factor under discussion was determined to be a critical success factor by the project participants (indicated by S), or whether it was merely a technique used to perform a function (indicated by T).

**DISCUSSION OF SUCCESS FACTORS AND RETROFIT PROJECT MANAGEMENT TECHNIQUES**

The section that follows discusses the success factors and lists the techniques we found in each topic area to successfully manage retrofit projects. In some cases we found little evidence of techniques, hence none are listed. The discussion focuses on ten areas.

It is important to note that these responses were based on questions asked and the respondent's perspective. Thus a technique special to retrofit projects may not be labeled as such by an engineer who only has experience on retrofit projects. Similarly a contractor who has only worked for one owner in the retrofit area may not mention the input of the owner as critical to a project.

**Project Team Characteristics (Factor No. 1)**

Responses to the questionnaire describing the characteristics of the project team were divided into its behavioral properties, and the time at which the team was formed. As noted earlier, two key behavior traits of a successful project team are a cohesive team with good chemistry and a flexible/decisive team. Included in this section is evidence of team building activities or techniques at both the project level and the site level. The team building exercises at the front end of the project are an effective technique to coalesce teams who have not previously worked together. One project had seven off-plot team building sessions ranging from one-half to one day each. Another project used Deming's 14 Points for quality management as a theme. One project team removed a superintendent who disrupted the team chemistry. Three projects had pre-outage, site wide parties to involve the crafts.
Table 3.1 shows the number of occurrences for each factor and the number of projects on which these were found to be critical. A key factor in attaining a successful team is to form the whole team early in the project's life and to include all players at that time. Key players were identified as the constructor, operator, maintenance supervisor, as well as the process, mechanical, and design engineers.

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Project Team Characteristics</td>
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<td>39</td>
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<td>1.1.</td>
<td>Project Team Behavior</td>
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<td>33</td>
<td>11</td>
</tr>
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<td>Cohesive Team With Chemistry</td>
<td>S</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>1.1.2.</td>
<td>Flexible/Decisive Team</td>
<td>S</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>1.1.3.</td>
<td>Team Building Techniques</td>
<td>T</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>1.1.4.</td>
<td>Site Level Team Building</td>
<td>T</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>1.2.</td>
<td>Project Team Formation</td>
<td>S</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3.1: Survey Data Describing Project Team Characteristics

S: Success Factor
T: Technique

Team Member Characteristics (Factor No. 2)

The characteristics of the project team that led to project success were divided into three key areas. Table 3.2 shows their relative importance. The first, input by the various project team members to the project team, was catalogued for the Owner, Engineer, Constructor, and Operator. In one case the owner's key staff were not available early in the planning phase. Two members cited early constructability input at key, while ten projects mentioned the operator's input as the key to success. The Operator's input seems to be most critical and hardest to obtain.

Secondly the experience of each team member was grouped for each of the Owner, Engineer, Operator, and the Trades. Several points are worth mentioning:

- Generally the contractor and owner personnel had been involved in the plant many years prior to the retrofit project studied (7 supporting cases).
- Three projects cited engineering experience in similar projects as essential to support the contractor. Two supported putting the estimating and process engineer representative on the design team.
• One respondent said that many Project Engineers (PEs) from the owner do not have the required experience for retrofit projects. Owners see these small projects as good training ground for young PEs, yet retrofit projects may be the hardest type of project to run.

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
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</tr>
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<td>2.1.1</td>
<td>Owner's Input</td>
<td>S</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2.1.2</td>
<td>Engineer's Input</td>
<td>S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.1.3</td>
<td>Constructor's Input</td>
<td>S</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2.1.4</td>
<td>Operator's Input</td>
<td>S</td>
<td>11</td>
<td>10</td>
</tr>
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<td>2.2</td>
<td>Team Member Experience</td>
<td>S</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
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<td>Owner's Experience</td>
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<td>2</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Engineer's Experience</td>
<td>S</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Operator's Experience</td>
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<td>6</td>
</tr>
<tr>
<td>2.2.4</td>
<td>Trades' Experience</td>
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<td>1</td>
</tr>
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<td>2.3</td>
<td>Team Member Skills</td>
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<td>Designer's Skills</td>
<td>S</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Constructor's Skills</td>
<td>S</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.3.4</td>
<td>Operator's Skills</td>
<td>S</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>2.3.4.1</td>
<td>Dedicated Operator Manpower/ Support</td>
<td>S</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2.3.4.2</td>
<td>Single Point of Contact with Operator</td>
<td>S</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3.2: Survey Data Describing Team Member Characteristics
S: Success Factor
T: Technique

Thirdly the various skills of the team members were grouped for the Owner, Designer, Contractor, and the Operator. Several key points worth mentioning here seem critical to project success (Number of instances are in brackets):
• The presence of a fair, realistic, decisive, project champion on the owner's team who wants the project to succeed (8 projects).
• Locate the designers on-site during design and construction (5 projects).
• Locate the contractors close to each other or in the same building and allow them to participate in procurement and inspection (2 projects).
• Assign dedicated operator manpower/support for the project duration (4 projects).
- Establish a single point of contact with operator (3 projects).

Contracting (Factor No. 3)
Contracting issues are divided into four categories in Table 3.3. The use of partnering agreements or de facto partnering situations was key to success in four cases. In four cases the wrong form of contract created adversarial relations in the team. In one case the use of multiple prime contracts prevented coordination. In another, the use of a partnering agreement that added a new team member, disrupted the whole project. In two cases severe contract language created adversarial relationships between parties. Contract incentives, both positive and negative, were used in four cases for the designers, contractors and labor unions. These included safety and attendance incentives, shared cost savings with unions, paying overtime on construction contracts, and penalizing designers for errors.

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>Contracting</td>
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<td>34</td>
<td>14</td>
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<tr>
<td>3.1.</td>
<td>Incentives</td>
<td>S</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>3.2.</td>
<td>Partnering Agreements</td>
<td>S</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>3.3.</td>
<td>Sub Contracting</td>
<td>S</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>3.4.</td>
<td>Procurement</td>
<td>S/T</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 3.3: Survey Data Describing Contracting
S: Success Factor
T: Technique

Several miscellaneous techniques for subcontracting and procurement are listed in Appendix F under section 3. Subcontracting techniques include use of specialty contractors and thorough checking of subcontractors before using them. Procurement techniques include: double buying inexpensive key material; using vendors with long term relationships for key vessels; procurement of key vessels before designing; on site fabrication of pipe; and using unit rate contracts for pipe.

Information Management (Factor No. 4)
Two types of information are considered in this section. The management of the design information was separated from plant information because the first was dependent on the project needs, while the second focused on the plant's constraints. Both the categories of design information, namely, management of the owner's information/ scope, and the design information, are of similar importance and significance (See Table 3.4).
Several techniques for managing the scope include:
- Maintaining good contact with marketing for scope changes (3 projects);
- Helping the owner understand the impact of their change (2 projects);
- Forcing the client to physically examine the space; and
- Limiting the number of options for users. In the case of multiple users, the user is restricted to selecting a design solution from three or four solutions preapproved for the whole group.

Techniques for managing design information include:
- Using electronic tools e.g., Autocad (4 projects);
- Using plastic models to communicate;
- Developing better estimating tools (2 projects); and
- Having the contractor make spool drawings.

The plant information had no dominant categories. Four equivalent techniques for determining plant information were:
- Site/plant visits by the team, which included walkdowns, field verification and showing scope on photos or P&IDs (6 projects);
- Knowledge about the plant that was obtained from contractor personnel who had been in the plant for several years (7 projects);
• In situ testing conducted by the owner and designer as required (8 projects); and
• Examining plant records (5 projects). It is important to note here that the government requires plant records to be kept for several industries.

Planning (Factor No. 5)
Table 3.5 shows that preplanning is divided into two key areas of similar importance. The first is strategic preplanning, the second is operational (tactical) planning. The strategic preplanning techniques included:
• Developing a similar job philosophy for all players (3 projects);
• Developing front end schedules with key milestones (5 projects); and
• Preplanning for prefabrication (2 projects).

Operational (tactical) planning techniques include:
• Involving the subcontractors, foremen and crafts in planning to buy in to all key milestone dates (4 projects);
• Developing short term lookahead schedules (3 projects); and
• Determining alternate scenarios to the main plan (2 projects).

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
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<tbody>
<tr>
<td>5.</td>
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<td>28</td>
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<td>5.1.</td>
<td>Preplanning</td>
<td>S / T</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>5.2.</td>
<td>Site Team Planning</td>
<td>T</td>
<td>15</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 3.5: Survey Data Describing Planning
S: Success Factor
T: Technique

Communications (Factor No. 6)
Four projects cited good communications as a key to project success. Table 3.6 shows that frequent meetings were the key element in communications. Respondents on 8 projects cited daily and weekly meetings as the key communication techniques.
<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Communications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Communications</td>
<td></td>
<td></td>
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<tr>
<td>6.2</td>
<td>Meetings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T</td>
<td>13</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3.6: Survey Data Describing Communications
S: Success Factor
T: Technique

**Time Management (Factor No. 7)**

Table 3.7 shows techniques to manage time during outages. The operator generally provided the time windows; and the contractors generally worked a variety of shifts to complete on schedule.

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>Time Management</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Time Windows</td>
<td>T</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>7.2</td>
<td>Shiftwork</td>
<td>T</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3.7: Survey Data Describing Time Management
S: Success Factor
T: Technique

**Space Management (Factor No. 8)**

The only significant technique found to manage space was coordination of the operations/construction interface (Table 3.8). Some techniques were:

- Construct tie-in work with maintenance forces if the maintenance scope during the shutdown is larger than construction work (5 projects);
- Get the contractor to conduct maintenance work if the construction scope is larger during the shutdown (1 project); and
- Allow both parties to work together if they have a good working relationship (2 projects).
Table 3.8: Survey Data Describing Space Management

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Space Management</td>
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<td>13</td>
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<tr>
<td>8.1</td>
<td>Operations/Construction Interface</td>
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<td>8</td>
<td>8</td>
</tr>
<tr>
<td>8.2</td>
<td>Other</td>
<td>T</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3.8: Survey Data Describing Space Management

S: Success Factor

T: Technique

Other techniques encountered on a lesser number of projects are listed in Appendix F.

Management of Working Environment (Factor No. 9)

Table 3.9 shows that techniques to manage the working environment were split between standards dictated by the owner/operator, and contractor techniques. Many clients (8 projects) had in-house safety procedures and programs and a permit system. Contractors focused on heat stress, dust and noise control, and rigging studies.

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Type</th>
<th>No. of Occurrences</th>
<th>No. of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Management of Working Environment: Owner/Operator Controlled Standards</td>
<td>T</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>9.1</td>
<td>Owner/Operator Controlled Standards</td>
<td>T</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>9.2</td>
<td>Contractor Techniques</td>
<td>T</td>
<td>13</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3.9: Survey Data Describing Management of Working Environment

S: Success Factor

T: Technique

Resources/ Support (Factor No. 10)

Table 3.10 shows that the supply of either resources or top management support were critical to success on five projects. No significant techniques were found.
This chapter analyzed the data collected from sixteen sites using two methods. First, the data sorted by question yielded the factors causing success on a project. Of these, the single factor most critical to success of a project was the characteristics of the project team and its members. A second analysis by data sorted by like topic identified techniques unique to retrofit projects. The reader should review Appendix F for a full listing of these techniques.
CHAPTER 4 - CONCLUSIONS

PROJECT SUMMARY

This research was exploratory in nature. As such, the results consist of a collection of opinions of factors causing success, evidence of techniques witnessed, and case study examples. When the project was initiated, the task force brainstormed the key issues in retrofit projects to be People, Knowledge, Materials, Technology, Space, Time, and Money. After a survey of the task force experts, the critical planning issues were found to be Information, Time, Space, and Environmental. Questions were developed to solicit input on the factors that were critical to the success of select retrofit projects and to determine any key techniques used to successfully complete these projects.

After analyzing the data by question, it appears that the key factors critical to the success of the project were the project team and the attributes of its members. Several techniques that led to success were termed success factors. Evidence for these was found to a lesser extent. These factors covered: contracting, procurement, scope management, plant knowledge, preplanning, communications, and resources and support. The reader must remember that the survey sought factors and techniques that were not typically used on grass roots projects, but we did not ignore those that were critical to success.

The second part of the analysis listed techniques within categories that were used effectively to manage retrofit projects. These are: team building; contracting (including procurement); managing design information; managing plant information; preplanning; communications; time; space; the working environment; and resources and support. The reader will note that some of those techniques are not unique to retrofit projects and are used on grass roots facilities.

DISCUSSION OF RESULTS

Table 4.1 shows the sources of data for each factor by each project visited. The X indicates that the item was mentioned as critical to success, or there was evidence of special techniques used to manage these retrofit projects. These are respectively indicated by S and T in the Type column of figure 4.1. The table also provides a summary of the number of projects on which evidence was found.
<table>
<thead>
<tr>
<th>Factor Name</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<td>S</td>
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<td>Project Team Behavior</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
<td>S / T</td>
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<td>Project Team Formation</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>S</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>S</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>S</td>
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X / Was mentioned as critical to success or found evidence of special techniques.

Table 4.1: Data Sources for Factors by Project
S: Success Factor
T: Technique
The absence of evidence on a project does not mean that the factor was not critical to a project's success. Rather it could support one of two scenarios. Firstly, the people interviewed may not have been aware that the techniques they used were unique to retrofit projects. This can be explained in that some had never worked on grass roots projects; all of their experience was retrofit work. On the other hand, project participants with grass roots construction backgrounds did provide more information on special techniques, because they had a different basis for comparison. A second explanation could be that in schedule driven projects, success is often measured by being able to produce the product on time. Economy or efficiency was a small piece of the success criteria in several cases. Thus, successful completion was key to success.

A similar argument can be made for the absence of special retrofit techniques. Retrofit projects have recently become recognized as a unique segment of the construction market. Previously, in many cases, these projects were completed by operations and maintenance staff and contractors located in facility complexes of plants. These people are now performing the retrofit projects for that facility. In some cases we could expect that typical techniques used to plan and manage maintenance and repair projects were used. In these cases, the project participants do not consider these techniques as special to retrofit projects.

**CRITICAL SUCCESS FACTORS**

In summary, the factors most critical to the success on retrofit projects all pertain to the project team. This team has several attributes which are:

1. The project team is cohesive and has developed good chemistry between the players.
2. The team is flexible and can respond to changes but is decisive.
3. The team is formed early in the project life and works together until the end.

In addition the team members exhibit the following characteristics:

1. The owner, engineer, constructor and operator provide early input from to the team.
2. The team members have experience in retrofit projects and in working in the given plant.
3. The owner has a decisive project champion who wants the project to succeed.
4. Design and construction contractors are located on the site close to each other for the project duration.
5. Operations provide a single point of contact and dedicated operator support.
COMMENTARY ON RESEARCH APPROACH

This research has been a first step towards defining a body of knowledge unique to retrofit projects. The input of task force members, who are experts in the field, helped form the basis for the study. The data collected from site visits provides important anecdotal evidence, however brief this may seem, to identify techniques critical to the success of retrofit projects.

Typically an exploratory approach, such as this, is the first method used to develop research. Future research should focus on building models of the retrofit process. These models are essential to better understand the topic and provide a benchmark for comparison. Several areas of research are essential to developing this knowledge. They are the areas of process modeling and critical success factors. We believe that methodologies used in these fields are essential to discovering knowledge about retrofit projects.

FUTURE RESEARCH

Based on a knowledge of research methods and processes, and the literature, the authors suggest several research projects to be considered by CII and this task force.

1 Develop a tool to select and build project teams.
   Develop a tool and guidelines that a project executive can use to select participating organizations and their individuals for a specific retrofit project. This tool should also describe methods for team building and team maintenance.

2 Develop a model of the retrofit process.
   Develop an objective model of the processes required to manage, plan, design, construct, and operate a retrofit project. Compare this to existing process models for conventional projects to objectively identify differences. Develop techniques to manage these differences.

3 Validate the Critical Success Factors for retrofit projects.
   Fully develop the critical success factors from prior research efforts. Develop questions to measure these factors and the success of the project. Select five pairs of similar retrofit projects from a given class and collect data and correlate results.
4 Develop a system of evaluating and monitoring the health of a retrofit project at various stages in its life.
Develop a system to allow a given user to evaluate health of project. This system could be a simple chart that could show the different functions for each agent. Test this method on a pilot study retrofit project.

5 Study the cost/ benefit/ of specific retrofit techniques and factors.
Identify several retrofit techniques of interest. Collect preoutage, outage, and post outage data on the conduct of the technique and its costs and benefits.

6 Develop a retrofit project educational package.
Develop a package to educate top managers and site personnel on the differences between retrofit and grass roots projects. Critical Success Factors and special techniques should be covered in detail.

CLOSURE

This research project has documented several key contributions. It has defined:

- A retrofit project.
- Factors critical to the success of retrofit projects.
- Techniques used to successfully manage retrofit projects.
- Future research thrusts to develop a body of knowledge on Retrofit Projects.

As the retrofit project becomes more important, it seems prudent to explore ways to make the process as efficient as possible. This research is seen as a first step in this exploration.
APPENDICES

A Retrofit Bibliography

B Data Collection Package

   B1 Task Force Letters
   B2 Project Orientation
   B3 Guidelines for Study Participants
   B4 Initial Questionnaire
   B5 Final Questionnaire
   B6 Data Confidentiality Policy

C Projects Surveyed

   C1 Project Profile
   C2 Projects Visited

D Task Force Meetings

E Survey Data Sorted by Question

F Survey Data Sorted By Topic
Appendix A. Retrofit Bibliography


Herrero, Jose C., and Osterlind, Philip. "How to execute industrial retrofit projects." Consulting/ Specifying Engineer, (May 1990), 41-45.
APPENDIX B1 - TASK FORCE LETTER NO. 1

American Cyanamid Company
Industrial and Performance Products Division
One Cyanamid Plaza
Wayne, NJ 07470

June 28, 1990

Dear

Ref: CII Retrofit Project Task Force Study.

Thank you again for the projects you submitted as candidates for the study to be conducted under the aegis of our task force. I am pleased that three or four of these projects have been selected for inclusion in our program.

I now ask for your assistance in arranging the details of the fact-finding sessions with our researchers. First, please confirm that the management of the owner, the engineer, and the principal constructor (if applicable) who were involved in the project(s) consent and support the inquiry by our researchers, and will make the key personnel available to participate. Second, please contact those key personnel and provide them with a clear understanding of the objectives, background, and procedures of our study. Third, please coordinate scheduling of the fact-finding sessions directly with Buck Riggs and Victor Sanvido, who are planning to visit on Thursday, July 26, 1990.

A copy of my presentation to the CII Board of Advisors is enclosed for your use in obtaining management consent and support and in briefing the people who will be participating. Also enclosed is a copy of the proposed format and procedure for the fact-finding sessions, a copy of our Data Confidentiality Policy, and the researchers’ resumes. The following facts should also be noted:

- We expect that the study will ultimately cover at least 30 projects. The projects to be included are selected to provide a broad and varied population. They will include both “successful” and “unsuccessful” projects (both can be valuable teachers). They are drawn from the process industries, heavy industry, utilities and commercial businesses. They will vary in size from tens of thousands of dollars to well over ten million dollars. They will represent geographic locations from east to west and north to south in the United States.
We expect that owners, engineers and constructors may not always agree about the success, the problems, and the effectiveness of project procedures for a given project. That's okay. Each party has somewhat different goals and perspectives, and those differences can be a source of enlightenment.

It cannot be overemphasized that the study will focus on the constraints that make retrofit projects so much more difficult than new construction projects; our budget and schedule are very limited, so we cannot devote our resources to rediscovering the basic principles of project management that apply to all jobs - new and retrofit.

Please call me if you have any questions, and do not hesitate to prompt me if I've overlooked anything. Thanks for your continuing efforts.

CC: Dr. L. S. Riggs
    Dr. V. E. Sanvido

Attachments:
1. Funding proposal, Retrofit Projects Task Force, with copies of "overheads" presented to the CII Board of Advisors.
2. Guidelines for study participants.
3. Data Confidentiality Policy
4. Resumes of researchers
American Cyanamid Company
Industrial and Performance Products Division
One Cyanamid Plaza
Wayne, NJ 07470

October 12, 1990

Dear

Ref: CII Retrofit Project Task Force Study.

Thanks again, for proposing three projects as candidates for the study to be conducted by our researchers. I am pleased to confirm that these projects have been selected for inclusion in our program. The fact-finding session for these projects has been tentatively set for the period Tuesday, November 6 - Wednesday, November 7, 1990.

I now ask that you, as primary liaison between the task force and the project team for these projects, arrange and coordinate some of the details for the interview session to be conducted by Buck Riggs and Victor Sanvido. Specifically, there are four tasks to be accomplished prior to the interview session:

1. Confirm that the managements of the owner, the engineer, and the principal constructor (if applicable) who were involved in the projects consent and support the inquiry by our researchers, and will make the key personnel available to participate.

2. Contact the project team principals (i.e. the owner’s representative, and if possible, the person responsible for operating the retrofit facility; the engineer’s project manager; and the constructor’s project manager and/or superintendent) and advise them of the objectives, purposes and procedures for the study. I cannot overemphasize the importance of this task. During some of the earlier sessions we ran into trouble that impaired the research process because an owner’s representative tried to control the inquiry and because an engineer’s project manager was reluctant to discuss project details for fear that his firm would receive an unfavorable rating. We are not rating anybody, just trying to learn why retrofit jobs go astray and how they can be executed more successfully.

3. Complete the expanded project profile forms for these projects and send them to Buck and Victor at least ten days prior to their visit. This will provide critical background information that will make their visit more productive. Copies should also be provided to the project team principals.
4. Coordinate schedules (times and locations) for the interview sessions directly with Victor and Buck.

A copy of my presentation to the CII Board of Advisors is enclosed for your use in obtaining management consent and support and in briefing the people who will be participating. Also enclosed is a copy of the proposed format and procedure for the fact-finding sessions, a copy of our Data Confidentiality Policy, and the researchers' resumes. The following facts should also be noted:

- We expect that the study will ultimately cover 15-20 projects. The projects to be included are selected to provide a broad and varied population. They will include both "successful" and "unsuccessful" projects (both can be valuable teachers). They are drawn from the process industries, heavy industry, utilities and commercial businesses. They will vary in size from tens of thousands of dollars to well over ten million dollars. They will represent geographic locations from east to west and north to south in the United States.

- We expect that owners, engineers and constructors may not always agree about the success, the problems, and the effectiveness of project procedures for a given project. That's okay. Each party has somewhat different goals and perspectives, and those differences can be a source of enlightenment.

- It cannot be overemphasized that the study will focus on the constraints that make retrofit projects so much more difficult than new construction projects. Our budget and schedule are very limited, so we cannot devote our resources to rediscovering the basic principles of project management that apply to all jobs - new and retrofit.

- Copies of the researchers' report (which CII refers to as a "source document") and the task force's project report publication will be made available for use by participants when they are completed.

Please call me if you have any questions, and do not hesitate to prompt me if I've overlooked anything. Thanks for your continuing efforts.

CC: Dr. L. S. Riggs
    Dr. V. E. Sanvido

Attachments:

1. Funding proposal, Retrofit Projects Task Force, with copies of "overheads" presented to the CII Board of Advisors.
2. Guidelines for study participants (9 sets).
3. Data Confidentiality Policy.
4. Resumes of researchers.
5. Project profile forms (3 copies).

WCK/sj-5847J
A retrofit project is the modification or conversion (not a complete replacement) of an existing process, facility or structure. Such modification may involve additions, deletions, rearrangements or not-in-kind replacement of one or more parts of the facility. Changes may alter the kind, quantity, cost or quality of the products or services being produced by the facility.
RETROFIT PROJECT

CONSTRAINTS

INFORMATION

TIME

SPACE

ENVIRONMENTAL
INFORMATION CONSTRAINTS

WHAT EXISTS
- P&ID's
- UNDERGROUND & FOUNDATIONS
- ELECTRICAL

USED EQUIPMENT
- CONDITION
- CAPACITY
- MANUALS

MATERIALS OF CONSTRUCTION,

DESIGN/CONSTRUCTION CODES AND STANDARDS

STRUCTURAL STRENGTH/INTEGRITY

UTILITIES
TIME CONSTRAINTS

SHUT-DOWN DURATION

SHUT-DOWN TIMING  - SCHEDULED
                 - UNSCHEDULED

CONSTRUCTION VS. MAINTENANCE

COMPETITION FOR TIME/ATTENTION OF OPERATIONS PERSONNEL
SPACE CONSTRAINTS

CONSTRUCTION
OFFICES
PARKING
LAYDOWN AREAS

ACCESSIBILITY - EXISTING FACILITIES

PEOPLE
RIGGING
SCAFFOLDING

CONSTRUCTION VS. MAINTENANCE

"MUSICAL CHAIRS"
ENVIRONMENTAL CONSTRAINTS

TEMPERATURE

PROCESS MATERIALS
  FLAMMABLES
  TOXICS

NOISE

VIBRATION

PRODUCT CONTAMINATION
WANTED

A COMPENDIUM OF
MANAGEMENT, ENGINEERING
AND CONSTRUCTION
TECHNIQUES
THAT ARE EFFECTIVE IN
AVOIDING, MITIGATING OR CONTROLLING
PROBLEMS CAUSED BY
RETROFIT PROJECT CONSTRAINTS
RETROFIT PROJECT TECHNIQUES

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CLEAR DEFINITION OF PROJECT OBJECTIVES
APPENDIX B3

GUIDELINES FOR STUDY PARTICIPANTS

TECHNIQUES FOR MANAGING, ENGINEERING AND CONSTRUCTING RETROFIT PROJECTS

Thank you for agreeing to participate in this research. The information you and others share with us about real-world experiences with retrofit projects will be the basis for the Retrofit Project Task Force’s report. Our objective is to provide to those involved in retrofit work a compendium of management, engineering and construction techniques that are effective in avoiding, mitigating or controlling problems caused by the constraints that are characteristic of retrofit projects in particular.

It is the purpose of these guidelines to tell you about the research methodology we are using so that you will know what to expect. That way you can be better prepared to provide the kind of information and documentation necessary to make our study productive.

The people who have been selected to participate in this study are those who, by virtue of their intimate involvement with specific retrofit projects, are in a unique position to provide reliable, factual information and knowledgeable opinions about the problems encountered and the effectiveness of techniques used to avoid, mitigate and control them. These participants ideally should include:

- **Owner’s representative(s)**
  - Project manager or engineer
  - Person responsible for operation of the completed facility.

- **Engineer’s representative**
  - Project manager.

- **Constructor’s representative**
  - Project manager, or Superintendent.

At least ten days before we visit your site, the CII Task Force member who is serving as liaison with your team will send us a completed project profile form, with a copy to you. This will enable us to get a feel for the project so we can be more productive during the visit.

The agenda for the visit will be as follows (times are approximate):

1. **Introduction** - a chance for us to get to know you, and for you to know us. (30 minutes)

2. **Site Tour** - (preferably with project representatives) to give us an idea of the working environment. (30-60 minutes)

3. **Interviews by Researchers** -
   a. Owner’s representative(s) (60 minutes)
   b. Engineer’s representative(s) (60 minutes)
   c. Constructor’s representative(s) (60 minutes)
The sequence of interviews shown above is preferred, but may be changed to accommodate personal schedules of the participants.

Attached to these guidelines are questions that indicate the kind of information we are seeking from the interview. You can facilitate the process by jotting down your responses on the question sheets before our visit, and giving us a copy at the beginning of the interview session. Copies of support documents will be most helpful. These questions are not meant to be all-inclusive, but they represent our best guess of key issues in retrofit projects. We are very interested in suggestions for additional important issues that are not conventional project management issues or techniques. Please feel free to add where appropriate.

We are particularly interested in any special techniques used in engineering, constructing and managing problems caused by the constraints of the specific retrofit projects under consideration. Please indicate whether any special techniques employed were successful, and tell what you might do differently if confronted with the same problems again. Please use specific references where possible; these will help ensure quality results.

Remember that conventional project management techniques are not the focus of this research (it has already been firmly established that good scope definition - for example - is a must). Address those conventional project management principles only if their impact was adverse or if they were not properly used.

We look forward to meeting you, and hope that jointly our efforts will make it possible to improve retrofit project execution for the benefit of owners, engineers, and constructors.

Dr. Leland S. Riggs
Associate Professor
Georgia Institute of Technology
School of Civil Engineering
Atlanta, GA 30332
404/894-2246
Fax: 404/894-2278

Dr. Victor E. Sanvido
Assistant Professor
Pennsylvania State University
Department of Architectural Engr.
104 Engineering Unit A
University Park, PA 16802
814/865-6395 or 865-2869
Fax: 814/863-4789

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GUIDELINES FOR STUDY PARTICIPANTS

TECHNIQUES FOR MANAGING, ENGINEERING AND CONSTRUCTING RETROFIT PROJECTS

Thank you for agreeing to participate in this research. The information you and others share with us about real-world experiences with retrofit projects will be the basis for the Retrofit Project Task Force's report. Our objective is to provide to those involved in retrofit work a compendium of management, engineering and construction techniques that are effective in avoiding, mitigating or controlling problems caused by the constraints that are characteristic of retrofit projects in particular.

The process for collecting data for this study comprises four steps:

1. **Written summaries** prepared by participants to provide an overview of specific selected projects.

2. **A brief tour** of the project site by the researchers to get a feel for the work environment, complexity, staffing levels, etc. (30-60 minutes).

3. **Oral presentations** by participants to elaborate on and discuss issues highlighted in their written submissions (60-90 minutes).

4. **A question and answer session** to allow the researchers to clarify and probe in greater depth those issues of particular significance (30-60 minutes).

The times indicated above are only approximations and may vary depending on the complexity of projects or other circumstances.

The "participants" referred to above ideally would include at least one representative each of the owner, the engineer (in-house or outside AE firm), and the principal constructor. These representatives must have been intimately involved in the project. It would also be useful to obtain input from those whose jobs involve operating or otherwise using the retrofit facility.

To assist the participants in preparing their submissions we have developed the attached guidelines. These guidelines are not meant to be all-inclusive, but they represent our best guess of key issues in retrofit projects. We are very interested in suggestions for additional important issues that are not conventional project management issues or techniques. Please follow these guidelines in your presentation, but feel free to add where appropriate.
The written accounts should focus on special techniques used in engineering, constructing and managing problems caused by the constraints of the specific retrofit projects under consideration. Also, please indicate whether any special techniques employed were successful, and tell what you might do differently if confronted with the same problems again. Please use specific references where possible; these will help ensure quality results.

Remember that conventional project management techniques are not the focus of this research (it has already been firmly established that good scope definition - for example - is a must). Address those conventional project management principles only if their impact was adverse or if they were not properly used.

The written submissions should be mailed not less than 10 days prior to our site visits. If you have any questions, do not hesitate to call us.

Dr. Leland S. Riggs
Associate Professor
Georgia Institute of Technology
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Atlanta, GA 30332
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Dr. Victor E. Sanvido
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University Park, PA 16802
814/865-6395 or 865-2869
Fax: 814/863-4789

WCK:sj-5391J
6/25/90
APPENDIX B4 - INITIAL QUESTIONNAIRE

1 Project Performance

1.1 What are the criteria you use to determine the degree of success on a project?

1.2 Describe how this project compares to your criteria.

1.3 What were the key factors that contributed to your successes on the project?

1.4 What key techniques did you employ to overcome obstacles?

1.5 List any special considerations used in the following areas on this project that helped you perform better:

- Contracts
- Payment Terms/ Incentive Plans
- Organization Forms
- Communication Techniques
- Risk Analysis

2 Information Management

What techniques did you use to determine:

2.1 The function, capacity and condition of the existing facility to be modified?

2.2 The state, capacity and location of the existing utilities and systems in the facility?

- Electrical
- Mechanical
- Plumbing

2.3 The strength and integrity of the structure and foundations?

2.4 The condition and capacity of any used equipment?

2.5 The materials of construction?

2.6 The codes/ standards to which the building was designed/built?
3 Time Management

What special techniques did you use to manage the following time constraints:

3.1 The shut-down duration?

3.2 The timing of the shut-down(s)?
   - Scheduled Shut-downs
   - Unscheduled Shut-downs

3.3 The balance between construction and maintenance activities during the shut-down period?

3.4 The available time / attention of operations personnel to the design/ construction team?

4 Space Management

How did you allocate and manage the following:

4.1 The location/ space available for:
   - Offices?
   - Parking?
   - Laydown Areas?

4.2 The accessibility to existing facilities for:
   - People?
   - Rigging?
   - Scaffolding?

4.3 The ratio between construction and maintenance spaces?

4.4 The rotation of players (construction trades, operations and maintenance personnel) through the spaces (Musical chairs)?
5 Management of Working Environment

What special techniques did you use to control the following work environment conditions:

5.1 The temperature of the work space?
5.2 The air quality?
5.3 The process materials e.g., flammables, toxics?
5.4 The noise generated by:
   The process plant?
   Construction operations?
5.5 The vibration generated by:
   The process plant?
   Construction operations?
5.6 The prevention of product contamination?

6 Personnel Management

What techniques did you use to:

6.1 Determine the ratio of manual to non-manual labor?
6.2 Communicate between the members in the project team?
   Off-site
   On-site
6.3 Assign responsibilities to team members?
   Within your organization
   Outside your organization
6.4 Mobilize critical personnel in time for various phases?
6.5 Motivate your direct personnel and craft labor?
   Incentive programs
   Motivation programs

7 Other

List any other special techniques you used to manage this project.
APPENDIX B5 - FINAL QUESTIONNAIRE

Product and Process Orientation

Please describe the product(s) to be manufactured in the retrofitted facility.

Describe the end uses?

Is it a new product?

What are its unique characteristics, e.g., hazardous, purity requirements?

Describe the level of visibility of the project in the company?

Describe the retrofit project justification.

- Environmental
- Cost reduction
- Safety
- Capacity
- Profit
- Market
- Quality

Describe the process technology.

Is it new?

Is the whole process being changed?

Describe key process steps, equipment and materials.
1 Project Performance

1.1 What are this project’s prioritized objectives?

1.2 Describe the extent to which these were met.

1.3 What were the key factors that contributed to your achievement of project objectives?

1.4 What were the key factors that prevented your achievement of project objectives?

1.5 What key techniques did you employ to overcome obstacles?

1.6 List any special considerations used in the following areas on this project that helped you perform better:

Contracts
Payment Terms/Incentive Plans
Organization Forms/Charts
Communication Techniques
Risk Analysis including Hazard Analysis
2  Planning

2.1 How did you identify and assess the key risks on the project? What was the impact of these risks on the project?

2.2 What techniques did you use to plan for contingencies? (e.g., what if analysis)

2.3 Describe your front end project planning before funds were committed.

2.4 What planning tools (give examples) did you use for engineering, procurement and construction?

2.5 What special techniques did you use to determine the balance between pre-shutdown and shutdown work?

2.6 How did the team plan for operability, constructability, and maintainability?

2.7 What techniques did you use to develop and freeze project scope?

2.8 What techniques did you use to plan the design basis and scope?

2.9 What techniques did you use to mobilize key personnel in time for various phases of the project?
Information Management

What techniques did you use to determine:

3.1 The function, capacity and condition of the existing facility to be modified?

3.2 The state, capacity and location of the existing utilities and systems in the facility?
   Electrical
   Mechanical
   Plumbing

3.3 The strength and integrity of the structure and foundations?

3.4 The condition and capacity of any used equipment?

3.5 The materials of construction?

3.6 The codes/standards to which the project was designed/built?
4 Time Management

What special techniques did you use to manage the following time constraints:

4.1 The shut-down duration?

4.2 The timing of the shut-down(s)?
   Scheduled Shut-downs
   Unscheduled Shut-downs

4.3 The balance between construction and maintenance activities during the shut-down period?

4.4 The available time / attention of operations personnel to the design/ construction team?
5 **Space Management**

How did you allocate and manage the following:

5.1 The location/ space available for:
   - Offices?
   - Parking?
   - Laydown Areas?

5.2 The accessibility to existing facilities for:
   - Designers?
   - Construction people?
   - Rigging?
   - Scaffolding?

5.3 The rotation of players, equipment and materials (construction trades, operations and maintenance personnel) through the spaces (Musical chairs)?
6 Management of Working Environment

What special techniques did you use to control the following work environment conditions:

6.1 The temperature of the work space?

6.2 The air quality?

6.3 The process materials e.g., flammables, toxics?

6.4 The noise generated by:
   The process plant?
   Construction operations?

6.5 The vibration generated by:
   The process plant?
   Construction operations?

6.6 The prevention of product contamination?

6.7 The ability to do hot work (spark producing operations) in operating units?

6.8 Making lifts over operational process units?
7 Personnel Management

What techniques did you use to:

7.1 Determine the amount of field construction engineers and field supervisors required to manage the given crafts?
   - Early in the project
   - At project peak
   - At project turnover

7.2 Communicate between the members in the project team?
   - Formal/informal

7.3 What surprises did the project team encounter and how did they respond to them?
   Please give examples.

7.4 Motivate your direct personnel and craft labor?
   - Incentive programs
   - Motivation programs

7.5 Instill teamwork in the project team?

8 Other

List any other special techniques you used to manage this project.

Please provide documentation that is unique (either in form, content or detail) to retrofit projects when compared to grass-roots facilities.
The Construction Industry Institute's primary goal is to advance the state of the industry through a series of well-directed study efforts. Success of these efforts depends on ready access to reliable company and project data, some of which may be proprietary. We recognize that compromising the confidentiality of proprietary data could be injurious to the companies who furnish the data. Therefore, certain procedures have been established to protect against such occurrences so that firms remain comfortable with entrusting proprietary data to CII, its task forces and/or researchers.

Research for this project will be conducted under CII's Level 2 (medium) confidentiality guidelines.

Specifically:

- Data will be provided by representatives of owners, engineers and constructors directly to the researchers.
- Persons submitting such data may remove company and or project identification from any document submitted.
- Raw data will be maintained by researchers in locked files with access restricted to the researchers and the CII Director and minimum additional staff on a need-to-know basis.
- If more than one copy of a given document is required, the originator will provide the correct number of copies and will record the copy number, e.g., 1 of 3, 2 of 3, etc. on each copy provided. It shall be prohibited for either a researcher or the CII staff to reproduce additional copies without prior written approval of the originator.
- In the rare instance where special security measures must be taken, a special confidentiality agreement may be entered between the data source and the researchers. It is understood that CII will honor all such agreements.
- Single data points can be published.
- Persons submitting confidential information to the researchers may specify that it be returned to the originator or destroyed after it has served the purpose for which it was intended.
RETROFIT PROJECTS STUDY

PROJECT PROFILE

Project Title: (Optional) ____________________________________________

Owner: (Optional) ________________________________________________

Engineer: _________________________________________________________

Constructor: _______________________________________________________

Approx. Cost (Circle Appropriate Figure): 2k$100, 2k$100 - <M$1.0, 2M$1.0 - <M$10, 2M$10-M$100, 2M$100

Project Type: Process Plant ______ Utility ______ Commercial ______

Date of Construction Completion: ________________________________

Project Duration (Months), Construction only _______________________

Total ___________________________________________________________

Was the existing facility occupied/operating during the construction period? __________

What was the duration of shutdown period(s)? ________________________

Was construction performed on a multi-shift work schedule? _________

What was the peak craft labor loading? ______________________________

Was the project particularly heavily weighted toward one or two craft areas? ____________________________

If so, which ones? _____________________________________________

Were any of the characteristic retrofit project constraints particularly severe? If so, what were they? _________________________________

Were there any other unusual circumstances that might make the project a particularly fertile source of retrofit project execution ideas? ____________________________________________

Project Nominated By (Name): ____________________________________

CI - 1
Project Profile (continued)

PRODUCT PRODUCED: ______________________
Is it a new product? yes __ no ___
END USE OF PRODUCT: ________________________________
IF PLANT CAPACITY INCREASE, BY WHAT PERCENT _______
DESCRIBE ANY UNIQUE CHARACTERISTICS WHICH INFLUENCE PROJECT'S
DESIGN AND CONSTRUCTION: ________________________________

BASIS OF PROJECT JUSTIFICATION:

Environmental __________________________
Cost Reduction _________________________
Quality ________________________________
Increased Production ___________________
New Technology ________________________
Safety _________________________________
Other _________________________________
If Other, identify _______________________

FACTORS POSSIBLY IMPACTING PROJECT EXECUTION:

High Visibility of Project to Management ______
Time limitations, including S/D Window ______
Delivery time of Special Equipment & Material ______

ORDER OF MAGNITUDE OF COST (OR LOST REVENUES) ASSOCIATED WITH
DELAY OF PROJECT COMPLETION (IF APPLICABLE)

$ _________ PER DAY or $ _________ PER MONTH

CONTRACT STRATEGY: (CHECK AS APPLICABLE)

<table>
<thead>
<tr>
<th>Contract Strategy</th>
<th>Engineering</th>
<th>Procurement</th>
<th>Construction</th>
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<tbody>
<tr>
<td>Cost Plus Fixed Fee</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Competitive L.S. Bids</td>
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<td></td>
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<tr>
<td>Negotiated Contract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Incentives</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONSTRUCTION APPROACH:

Prime Contractor using Direct Hire Labor ______
Construction Management using all Subs. ______
Subcontracts By Owner ______
Subcontracts By Others ______
APPENDIX C2 - PROJECTS VISITED

<table>
<thead>
<tr>
<th>PROJECT NUMBER</th>
<th>TYPE</th>
<th>SIZE $MM</th>
<th>TOTAL TIME MONTHS</th>
<th>CONSTRUCTION TIME MONTHS</th>
<th>SHUTDOWN TIME MONTHS</th>
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<tr>
<td>1</td>
<td>Power</td>
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<td>1.5</td>
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<td>12</td>
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<td>12</td>
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<td>2.75</td>
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<td>22</td>
<td>12</td>
<td>0.5 / 0.5</td>
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<td>7</td>
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<td>1</td>
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<td>24</td>
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<td>10-100</td>
<td>21</td>
<td>13</td>
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<td>11</td>
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<td>9</td>
<td>6</td>
<td>0</td>
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<td>21</td>
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<td>2</td>
<td>0.5</td>
<td>0 / *</td>
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<td>0 / *</td>
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<td>12</td>
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<td>100+</td>
<td>34</td>
<td>24</td>
<td>0.25 / 0.5 / 0.8 / 1.4</td>
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</table>

* The work was phased and functions were moved into new space, then the vacated area was retrofitted.
## APPENDIX D - TASK FORCE MEETINGS

<table>
<thead>
<tr>
<th>DATE</th>
<th>LOCATION</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/89</td>
<td>Austin, TX</td>
<td>Orientation</td>
</tr>
<tr>
<td>8/89</td>
<td>San Diego, CA</td>
<td>Reviewed Literature, Retrofit Definition, Preliminary Questionnaire</td>
</tr>
<tr>
<td>10/89</td>
<td>Stamford, CT</td>
<td>Bechtel Case Study, Weyerhauser Presentation, John Brown Presentation,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify Planning Elements key to Retrofit Project</td>
</tr>
<tr>
<td>11/89</td>
<td>Pittsburgh, PA</td>
<td>Redefined Project Scope</td>
</tr>
<tr>
<td>1/90</td>
<td>Tampa, FL</td>
<td>Badger Presentation, Weyerhauser Presentation</td>
</tr>
<tr>
<td>3/90</td>
<td>Houston, TX</td>
<td>Lummus Crest Presentation, Redefined Project Objectives, Project Proposal</td>
</tr>
<tr>
<td>5/90</td>
<td>Beaver Creek, CO</td>
<td>Selected Candidate Projects, Reviewed Guidelines, Scheduled Site Visits</td>
</tr>
<tr>
<td>8/90</td>
<td>Nashville, TN</td>
<td>Presented Preliminary Results, Modified Guidelines, Rescheduled Site Visits</td>
</tr>
<tr>
<td>2/91</td>
<td>Atlanta, GA</td>
<td>Site Visit Status Report (Projects 6 - 13), Future Plans</td>
</tr>
<tr>
<td>5/91</td>
<td>Austin, TX</td>
<td>Reviewed All Data, Discussed Report Format</td>
</tr>
</tbody>
</table>
APPENDIX E - SURVEY DATA SORTED BY QUESTION

The following results were obtained from 16 sites visited from July 25, 1990 to April 30, 1991. All answers are listed under each heading.

1 PROJECT PERFORMANCE

Success criteria vary significantly between client satisfaction, safety, quality, budget, schedule, profit. Key success factors include:

1.1 Project Team
3, 12 Cooperative teamwork/ Good chemistry
4 Locate designer on site.
4 Locating contractors in the same office to improve communications.
4, 7 A single point of contact with operator
5 Strong team champion.
6 Experienced capable project team
7 A line organization for the project rather than matrix
7 Dedicated operator manpower
7 Early scope design. Operator was lead designer.
9 Brought many new people in - trained them.
9 Good operator input/ support
9 Off plot team building sessions to get a team approach 7 x 1/2 to 1 day sessions
9 Use of team building efforts
12 Team had quick response to problems
13 Have one client representative
14 Cohesive team with good chemistry between contractor / owner representatives
15 AE / Owner had good relationship

1.2 Resources/ Support
3 Top management attention to project.
4 Having engineering, construction, and operations resources available on site.
11 Good resource commitments
11 High visibility in company

1.3 Contracting
1 Designer incentives for reducing errors and completing documents by key milestones.
1, 2, 9 Contractor incentives for cost, schedule, and other "performance" judged by owner.
1, 2, 11 Good partnering agreements with engineer and contractor
5 Having plant agreements with engineers and contractors for services required for these projects.
15, 16 Severe contract

1.4 Preplanning
6 Early plant interface in scope development, planning and execution
6 Extensive preplanning to minimize shutdown duration
6, 9 Early constructability input, reviews and analysis
9 Agreement on priorities

1.5 Information Management
9 Realistic cost estimate
12 Good communications
12 Limiting the number of options for users

1.6 Communications
3 Weekly meetings for all project teams
3, 7 Daily contractor/owner meeting

Key causes of failure were:

1.7 Project Team
8 Ten prime contractors
10 Had engineer on board - top management thrust a new designer on them at 3x fee through a partnership agreement
11 Many PEs are in training for owner
16 Could not agree on CM/Owner roles
16 Engineer could not keep up with contractor
16 No Owner project manager

1.8 Information
10 Deficiency in P & I/E work
10 Late isos
10 Scope changes
16 Poor maintenance input

1.9 Size
8 Job was too large

2 PLANNING

2.1 Project Team
1 Involve foremen and crafts in planning to buy into key dates.
1 Reviewed similar project by another contractor on site
3 Paying overtime on construction contracts
5 Superintendent was on site for 20 years with another company.
6 CM, operator and maintenance people were assigned early
7 Operations and marketing defined market for product
7 Process and design engineers worked together to define scope / production
9, 11 Good input from operator, maintenance, and contractor
11 Flexible project team
11 Had quick decisions from client
12 Contractors were in building as maintenance workers for a long time
12 Planning done with client in meetings
14 CM/Owner coordinated and managed the architect
2.2 Short Term Plans
1, 11 Had alternate work plans for several parallel units. Driven by operational directions
2 Daily meetings with Operator / Engr. / Contractor for critical activities.
2 Weekly meetings for non critical items
4 Weekly meeting with CM / Subcontractors
4 Weekly meeting with owner / CM
5, 6 Daily / weekly / monthly planning cycles
13 Used night shift
16 Drawings came by fax
16 Two day lookahead schedule

2.3 Long Term Plans
2 Planned for prefabrication
5 Front end schedule with key milestones
6 Conceptual study
15 Used subs to develop schedule

2.4 Procurement
3 Double buying cheap, key material.
3 Paying vendors premiums to expedite key equipment and materials.
3 Using vendors with long term relationships with company for key vessels.

2.5 Others
2 Field Walkdown prior to shutdown
5, 9 Bought key equipment then designed plant
10 Good operator input to plans
10 Process engineer reviewed PFD's
16 Organization charts
16 Photos - check vs drawings
16 Preassembly before shutdown

Key causes of failure were:

8 It Took up to 4 days to get a decision
10 Poor communication with engineer
10 Poor definition of scope changes
14 Did not review subs in detail before contracting with them.
15 Low CM input
15 Low operator input
15 Very little experience

3 INFORMATION MANAGEMENT

3.1 Site / Plant Visits
1, 2, 3 Contractor had good knowledge of plant
1, 2, 7, 10 Field verification
6 Designers visited plant to get operator's input
3.2 In Situ Tests
3 Open up the building and look
3, 4, 9, 11 In situ testing
11 Opened up equipment
14 The contractor opened up the structure and examined systems
15 Opened up building to examine architectural/structural finishes and the elevators
16 X-rays/cores

3.3 Records
1, 2, 5, 6 Good plant records (Required by law)
8 No records available
11 Photographs
16 Poor records

3.4 Project Team
1 Designers were penalized for errors
1, 2, 3, 8 Operator had knowledge of plant
1, 2, 10, 12, 13 Contractor had maintenance contract
4 Operability change came too late
5 Good contact with operators
5, 7 Designers on site in trailer - kept 6 on site during construction
7 Contractor made spool drawings
8 Good contact with marketing for change communication
8 Weekly meetings
10 Shutdown meetings each day
10 Transfer design from designer to contractor
11 Operator on site
14 Frequent meetings

3.5 Analysis
6 Operator tested software before installation
8 Showed scope on P & ID's of plant
8 Special studies
9 Built a model of area
10 Engineering was offsite. Led to errors in dimensions.
14 Architect had to redesign for owner changes in new technology
7 Drew scope of work on photos

4 TIME MANAGEMENT
1 Involved operator early
1 Single job philosophy for all parties
1, 4, 5 Generally this was dictated by the shut down.
2 Developed job philosophy between day and night crews
2 Involved foremen
3 Facility was shut down
7 Hard to get operator's attention until they take the plant over
7 Standard time lines
Classes given to operators on new facility
Daily shut down meetings
Daily status reports
Safety operators controlled project
Use a system basis for work
Had 4 operators up to 8 full time
Used scheduling software
Operations dictated schedule
Key people were not available early on
Worked off shift hours
Contractor had windows of time by area from the operator
Nightshifts used when needed
Available operator input
Early second shift
Lookahead schedules

5 SPACE MANAGEMENT

A/E checked rigging
Used the same contractor for O&M work and construction during outage
Build new work while unit was operational
Used space inside building
Used staggered shifts and second shifts
Plant maintenance did work during shutdown
Craft density loading
Had to prepare and shutdown after each day's work for fire truck access
Maintenance had 85% of SD work, constructor 15% (tie ins)
Permits
Plant provided flanges at both ends of project thus no tie in by contractor
Knew building users and worked with them
Handed over new structure / then remodeled existing
Phased released to contractor
Building was operational, time / space allocated by operator
By Owner

6 MANAGEMENT OF WORKING ENVIRONMENT

6.1 Owner / Operator Controlled Standards
Client safety procedures and permits
Fire watch
Operations controlled
The owner/operator monitored this.
Noise and dust managed by CM/Owner
Fans/temperature protection
These were dictated by the site safety manager and inspectors.

6.2 Contractor Techniques
Dressed in protective clothing
Used heat stress curves to regulate work times
1, 4 Air quality contractor
4, 10 Heat in summer - extra breaks / liquids
4, 12 Dust Walls
7 Plant safety and rigging studies
7 Switched to all bolt up work - no hot work
12 Performed painting and noisy operations off hours
13 Remove flammables after shift

7 PERSONNEL MANAGEMENT

7.1 Site Wide
1 A pre-outage get together for all personnel and crafts with families was successful in building team spirit.
3 The attention of high level people in the participant's organization was key to mobilizing key people and motivating them - although micro-management on one project took its toll.
6 Party for team
10 Low skilled labor market
10 Removed superintendent

7.2 Planning
6 Foreman assigned to planning team
6 Planned work activities and required man-hours to limit craft densities
10, 12 Informal daily planning

7.3 Communications
1 Safety and attendance incentives
1 Shared cost savings with unions
8 Quality Improvement meetings with contractors
10 Experience of engineers hampered jobs
10 Very informal job
11 Good communication / listening
11 Weekly / Daily meetings

8 OTHER

1 Management by walking around (owner)
2 Sharing savings from project with unions.
4 Use specialty contractors
5 Fabricate pipe on site
5 Paralleling mechanical and supporting (structural, electrical) design on site during construction.
5 Using Autocad for updating P&IDs
7, 8 Good open communications
8 Deming's 14 points
8 Flexibility
8 Lunch together - theme days
8 Patience
9 Have one large office at jobsite
10 Estimate needs better (more time)
10 Have control over schedule
10 Let PM select their designer
11 Good top management support
11 Process engineer on team
14 Used Autocad
15 Asbestos removal/ Special techniques included:
16 Cooperation from company to get key people
16 Good scope/ documents

9 KEY LESSONS LEARNED

9.1 Project Team
4 Let contractor procure materials, expedite, and inspect
4 Owner had design done out of house since that project
4, 9 Get contractor on board earlier for design / procurement phases
6 Get experienced people; take time to plan job
8 Get good people (experienced)
8 Get someone (project manager) who wants the project to succeed as PM
8 Put estimating in engineering
9 Get mechanical and process people together sooner
10 Design company - animosity between designers
10 Designer intruded - did not know team - fragmented team
10 Would have liked constructability reviews / input
11 Get a single plant representative who is knowledgeable, decisive, has authority
11 Operations view construction as a nuisance to them
11 Trades have been on site +/- 5 years (45%)
12 Develop a good team
14 Chemistry of team is key

9.2 Procurement
10 Release isos to vendors and use unit rate contracts not lump sum

9.3 Resources
8 Get resources $ / material
8 Get sufficient time (pushed project too fast)

9.4 Contracting
6 Manage software as a separate project
10 Job was too small for partnership

9.5 Communications
1 Design team at the end of the project
1 Sell designs to operators
8 Do better front end engineering
9 Improve safety
9 Simpler schedule presentations
15 Add % to regular work for renovation work
15 Document decisions clearly
15 Large scale work is tougher
15 More leaseup before start
10 DESIRED RETROFIT TOOLS

10.1 Project Team
6 Develop chemistry in team
10 Build a relationship
13 Task force to look at good facility requirements

10.2 Information
1 Force client to examine the space
1 Use plastic models to communicate
6 Better electronic communications between staff
6 Better plant input to project (use same people for whole job)
6 Better tools to predict cost / schedule in design
13 Use of CAD to automate component drawings and take offs
14 Communicate achievement of the team to the owner
14 Help owner understand impact of change
APPENDIX F - SURVEY DATA SORTED BY TOPIC

1

PROJECT TEAM CHARACTERISTICS

1.1

Project Team Behavior

1.1.1 Cohesive Team With Chemistry

1 Design team available at the end of the project
3, 12 Cooperative teamwork/ Good chemistry
6 Experienced capable project team
6 Develop chemistry in team
10 Had engineer on board - top management thrust a new designer on them at 3x fee through a partnership agreement
10 Designer intruded - did not know team - fragmented team
10 Design company - animosity between designers
10 Build a relationship
10 Removed superintendent
11 Operations view construction as a nuisance to them
12 Develop a good team
14 Chemistry of team is key
14 Cohesive team with good chemistry between contractor / owner representatives
15 AE / Owner had good relationship
16 Could not agree on CM/ Owner roles

1.1.2 Flexible/ Decisive Team

7 A line organization for the project rather than matrix
8 Flexibility
10 Transfer design from designer to contractor
11 Flexible project team
12 Team had quick response to problems
16 Organization charts

1.1.3 Team Building Techniques

8 Deming’s 14 points
8 Patience
9 Off plot team building sessions to get a team approach 7 x 1/2 to 1 day sessions
9 Brought many new people in - trained them.
9 Have one large office at jobsite
10 Let PM select their designer

1.1.4 Site Level Team Building

1 A pre-outage get together for all personnel and crafts with families was successful in building team spirit.
3 The attention of high level people in the participant’s organization was key to mobilizing key people and motivating them - although micro-management on one project took its toll.
6 Party for team
8 Lunch together - theme days
10 Low skilled labor market
1.2  Project Team Formation
4, 9  Get contractor on board earlier for design / procurement phases
6  CM, operator and maintenance people were assigned early
7  Process and design engineers worked together to define scope / production
7  Hard to get operator's attention until they take the plant over
9  Get mechanical and process people together sooner

2  TEAM MEMBER CHARACTERISTICS

2.1  Project Team Member Input

2.1.1  Owner
6  Early plant interface in scope development, planning and execution
11  Key people were not available early on
12  Planning done with client in meetings

2.1.2  Engineer
10  Poor communication with engineer

2.1.3  Constructor
2  Involved foremen
6, 9  Early constructability input, reviews and analysis
10  Would have liked constructability reviews / input

2.1.4  Operator
1  Involved operator early
5  Good contact with operators
6  Better plant input to project (use same people for whole job)
8  Classes given to operators on new facility
9, 11  Good input from operator, maintenance, and contractor
10  Good operator input to plans
14  Good operator input
15  Low operator input
15  Low CM input
16  Poor maintenance input

2.2  Team Member Experience

2.2.1  Owner
11  Many PEs are in training for owner
15  Very little experience

2.2.2  Engineer
4  Owner had design done out of house since that project
8  Put estimating in engineering
10  Experience of engineers hampered jobs
11  Process engineer on team
16  Engineer could not keep up with contractor

2.2.3  Operator
1, 2, 3, 8  Operator had knowledge of plant
6  Get experienced people; take time to plan job
8  Get good people (experienced)
15  Very little experience

F - 2
2.2.4 Trades
11 Trades have been on site +/- 5 years (45%)

2.3 Team Member Skills

2.3.1 Owner
1 Management by walking around (owner)
5 Strong team champion.
8 Get someone (project manager) who wants the project to succeed as PM
8 It took up to 4 days to get a decision
11 Had quick decisions from client
13 Have one client representative
14 CM/Owner coordinated and managed the architect
15 Realistic fair client
16 No Owner project manager

2.3.2 Designer
4 Locate designer on site.
5, 7 Designers on site in trailer - kept 6 on site during construction
8 Do better front end engineering
10 Engineering was offsite. Led to errors in dimensions.
15 Paralleling mechanical and supporting (structural, electrical) design on site during construction.

2.3.3 Construction Contractor
4 Locating contractors in the same office to improve communications.
4 Let contractor procure materials, expedite, and inspect

2.3.4 Operator
2.3.4.1 Dedicated operator manpower/support
7 Dedicated operator manpower
9 Good operator input/support
9 Had 4 operators up to 8 full time
11 Operator on site
16 Available operator input

2.3.4.2 Single point of contact with operator
4, 7 A single point of contact with operator
7 Early scope design. Operator was lead designer.
11 Get a single plant representative who is knowledgeable, decisive, has authority

3 CONTRACTING

3.1 Incentives
1 Safety and attendance incentives
1 Shared cost savings with unions
1 Designer incentives for reducing errors and completing documents by key milestones.
1 Designers were penalized for errors
1, 2, 9 Contractor incentives for cost, schedule, and other "performance" judged by owner.
2 Sharing savings from project with unions.
3 Paying overtime on construction contracts
3 Paying vendors premiums to expedite key equipment and materials.
3.2 Partnering Agreements
1, 2, 11 Good partnering agreements with engineer and contractor
5 Having plant agreements with engineers and contractors for services required
   for these projects.
8 Ten prime contractors
8 Job was too large
10 Job was too small for partnership
15 Large scale work is tougher
15, 16 Severe contract

3.3 Sub Contracting
4 Use specialty contractors
6 Manage software as a separate project
6 Operator tested software before installation
14 Did not review subs in detail before contracting with them.
15 Asbestos removal specialists
15 More leaseup before start
15 Revised tenant work letter

3.4 Procurement
3 Double buying cheap, key material.
3 Using vendors with long term relationships with company for key vessels.
5 Fabricate pipe on site
5, 9 Bought key equipment then designed plant
10 Release isos to vendors and use unit rate contracts not lump sum
13 Used night shift

4 INFORMATION MANAGEMENT

4.1 Design Information Management

4.1.1 Owner's Info/ Scope Management
1 Force client to examine the space
4 Operability change came too late
7 Operations and marketing defined market for product
8 Good contact with marketing for change communication
10 Process engineer reviewed PFD's
10 Poor definition of scope changes
10 Scope changes
12 Limiting the number of options for users
13 Task force to look at good facility requirements
14 Architect had to redesign for owner changes in new technology
14 Help owner understand impact of change
14 Communicate achievement of the team to the owner
16 Good scope/ documents

4.1.2 Design Info
1 Sell designs to operators
1 Use plastic models to communicate
5 Using Autocad for updating P&IDs
6 Better electronic communications between staff
6 Better tools to predict cost / schedule in design
7 Contractor made spool drawings
Realistic cost estimate
Late isos
Deficiency in P & I/E work
Use of CAD to automate component drawings and take offs
Used Autocad
Add % to regular work for renovation work
Document decisions clearly
Drawings came by fax

4.2 Plant Information Management

4.2.1 Site/ Plant Visits
Field verification
Field Walkdown prior to shutdown
Drew scope of work on photos
Showed scope on P & ID's of plant
Built a model of area
Photos - check vs drawings
Preassembly before shutdown

4.2.2 Plant Knowledge
Contractor had good knowledge of plant
Contractor had maintenance contract
Superintendent was on site for 20 years with another company.
Designers visited plant to get operator's input
Contractors were in building as maintenance workers for a long time

4.2.3 In Situ Tests
Open up the building and look
In situ testing
Special studies
Opened up equipment
The contractor opened up the structure and examined systems
Opened up building to examine architectural / structural finishes and the elevators
X-rays/ cores

4.2.4 Plant Records
Good plant records (Required by law)
No records available
Photographs
Poor records

5 PLANNING

5.1 Preplanning
Reviewed similar project by another contractor on site
Single job philosophy for all parties
Planned for prefabrication
Developed job philosophy between day and night crews
Front end schedule with key milestones
Extensive preplanning to minimize shutdown duration
Conceptual study
Standard time lines
8 Use a system basis for work
9 Used scheduling software
9 Agreement on priorities
9 Simpler schedule presentations
16 Lookahead schedules

5.2 Site Team Planning
1 Involve foremen and crafts in planning to buy into key dates.
1, 11 Had alternate work plans for several parallel units. Driven by operational
directions
5, 6 Daily / weekly / monthly planning cycles
6 Foreman assigned to planning team
6 Planned work activities and required man-hours to limit craft densities
8 Quality improvement meetings with contractors
10 Very informal job
10 Have control over schedule
10, 12 Estimate needs better (more time)
15 Used subs to develop schedule
16 Two day lookahead schedule

6 COMMUNICATIONS

6.1 Communications
7, 8 Good open communications
11 Good communication / listening
12 Good communications

6.2 Meetings
2 Daily meetings with Operator / Engr. / Contractor for critical activities.
2 Weekly meetings for non critical items
3 Weekly meetings for all project teams
3, 7 Daily contractor/ owner meeting
4 Weekly meeting with CM / Subcontractors
4 Weekly meeting with owner / CM
8 Daily shut down meetings
8 Daily status reports
8 Weekly meetings
10 Shutdown meetings each day
11 Weekly / Daily meetings
14 Frequent meetings

7 TIME MANAGEMENT

7.1 Time Windows
1, 4, 5 Generally this was dictated by the shut down.
3 Facility was shut down
8 Safety operators controlled project
10 Operations dictated schedule
14 Contractor had windows of time by area from the operator

F - 6
7.2 **Shift work**
3 Used staggered shifts and second shifts
12 Worked off shift hours
15 Nightshifts used when needed
16 Early second shift

8 **SPACE MANAGEMENT**

8.1 **Operations/ construction interface**
1 Used the same contractor for O&M work and construction during outage
5 Plant maintenance did work during shutdown
10 Maintenance had 85% of SD work, constructor 15% (tie ins)
11 Plant provided flanges at both ends of project thus no tie in by contractor
12, 13 Knew building users and worked with them
15 Building was operational, time / space allocated by operator
16 By Owner

8.2 **Other**
1 A/E checked rigging
1, 2 Build new work while unit was operational
3 Used space inside building
6 Craft density loading
7 Had to prepare and shutdown after each day’s work for fire truck access
11 Permits
14 Handed over new structure / then remodeled existing
14 Phased released to contractor

9 **MANAGEMENT OF WORKING ENVIRONMENT**

9.1 **Owner / Operator Controlled Standards**
1, 5, 6, 8, 9
10, 11 Client safety procedures and permits
9 Fire watch
9 Operations controlled
14 The owner/ operator monitored this.
15 Noise and dust managed by CM / Owner
16 Fans/ temperature protection

9.2 **Contractor Techniques**
1 Dressed in protective clothing
1 Used heat stress curves to regulate work times
1, 4 Air quality contractor
4, 10 Heat in summer - extra breaks / liquids
4, 12 Dust Walls
7 Plant safety and rigging studies
7 Switched to all bolt up work - no hot work
9 Improve safety
12 Performed painting and noisy operations off hours
13 Remove flammables after shift
10 RESOURCES/ SUPPORT

10.1 Resources
4 Having engineering, construction, and operations resources available on site.
8 Get resources $ / material
8 Get sufficient time (pushed project too fast)
11 Good resource commitments

10.2 Support
3 Top management attention to project.
11 High visibility in company
11 Good top management support
16 Cooperation from company to get key people