# PRODUCTIVITY IMPROVEMENTS ON ALBERTA MAJOR CONSTRUCTION PROJECTS

## PHASE I – BACK TO BASICS

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## EXECUTIVE SUMMARY

The construction industry has gained the reputation of being one of the most challenging and demanding, with still many opportunities for productivity improvement.

Recently in Alberta, we have noticed a trend for some large industrial projects to overrun cost and schedule. There is a concern that if this trend is not reversed, whatever the reasons, it will erode Alberta's competitiveness in construction.

Increased productivity can have a large impact on the overall construction process and consequently result in significant cost and time savings, i.e. capital cost on the construction projects.

This report deals with various aspects of construction productivity, including basic concepts, factors and major issues affecting productivity. A total of 208 poorly managed construction activities were identified and described.

These activities have been grouped under the following categories:

- Material delivery and control
- Constructability
- Waiting time
- Construction equipment
- Site layout and temporary facilities
- Poor work planning and utilization of labour
- Unproductive work
- Assumptions and authority

A detailed set of practical recommendations, suggesting corrective action to deal with many of the 208 poorly managed activities is provided. These recommendations outline methods on how to improve and enhance the Alberta Advantage relative to construction performance.

The authors also propose a tool to enable contractors and owners to evaluate project performance against a defined baseline. This tool is based on industry project audit reports and the authors' professional experience. For the tool to be used by construction firms and individuals, customization is recommended for application to each specific project.

In order to evaluate a project, 14 key components are identified and given a weight (out of 100). These key components and their associated weight are:

| Key Components: | Weight (%) |
|---|---|
| • Cost management | 6% |
| • Schedule management | 10% |
| • Work planning | 12% |
| • Progress and productivity | 10% |
| • Quality management | 8% |
| • Safety management | 8% |
| • Organization | 7% |
| • Labour relations | 7% |
| • Material management | 12% |
| • Subcontract administration | 6% |
| • Managing construction equipment | 4% |
| • Management of construction tools | 4% |
| • Management of temporary facilities | 3% |
| • Scaffolding management | 3% |
| | 100% |

Each key component is further divided into its basic elements. Each element is also assigned a weight.

Any opportunity to achieve productivity improvements over the historical norm will require better planning. The Construction Manager's strategy should be based on the ability to reduce non-productive time, or to increase time available for direct work. Providing complete work packages and not releasing them for construction until all elements of the work package are in place can further this objective.

This productivity improvement strategy includes providing the right drawings, pre-bagged materials, instructions for tool sizes, scheduled equipment and also assuring that specific procedures are referenced, permits in place, pre-requisite work is completed, etc. This system is based on a commitment to establish a planning group whose responsibility is to develop and maintain a backlog of available work order packages, ready to be released for construction.

Productivity improvement is actually a reduction in the non-productive time spent each day by the worker and a transfer of those man-hours to direct productive work. Our estimate of the potential savings impact could range from between 10 to 30%.

It is to be noted that a number of other factors may contribute to the potential savings from the estimated range indicated, including the degree of off-site fabrication and modularization, the subcontracting strategy and schedule, and the commercial terms of the contract.

However, it is obvious that a productivity improvement program provides the most significant opportunity available to management to affect major cost reductions and that huge multiplier effects can be achieved in project cost savings from a relatively small investment in early front-end construction planning.

# 1.0 INTRODUCTION

This section presents a brief background of construction productivity, and the challenges facing the construction industry. The section also includes the purpose of the study and the scope of the assignment and methodology used.

## 1.1 Background

Construction is the single largest industry in economic output and in the number of people employed as well[1]. In Canada, the construction industry represents 5.3% of the total employment. The construction gross domestic product (GDP) of $99 billion provides 12% of the nation's total GDP[2].

A successful construction project is one that achieves the intended objectives in terms of cost, time, quality and safety. This is possible only when the planned levels of productivity can be attained. However, productivity, or lack of it, is perhaps one of the main problem confronting the construction industry, the construction firm and the construction project[3]. As a consequence of the importance of the construction industry, the nature of construction projects and the available economic resources, more emphasis should be given to improving productivity.

Construction is a labour-intensive process. Manpower is one of the productive resources in construction; therefore, construction productivity largely depends upon human performance[4]. Therefore, the most reliable measure of productivity is the output per work-hour being achieved by the workers at the construction site – the on-site labour productivity.

On-site labour costs typically contribute 30% to the overall project's costs[1], so maximizing on-site labour productivity is an important area to focus attention in order to reduce the capital cost of the construction project. Figure 1 following shows a breakdown of time utilization by construction workers[5].

On average, workers spend 55.5% of their working time (excluding official times) on productive activities, 2.1% on supervision-related activities, 13% on "extra breaks", and 29.4% unproductively. The extra breaks consist of early quits and late starts; clearly a loss of 13% is considerable for a typical construction site. Overall, Figure 1 provides a warning for a construction manager and indicates that opportunities for significant improvement in labour productivity exist.

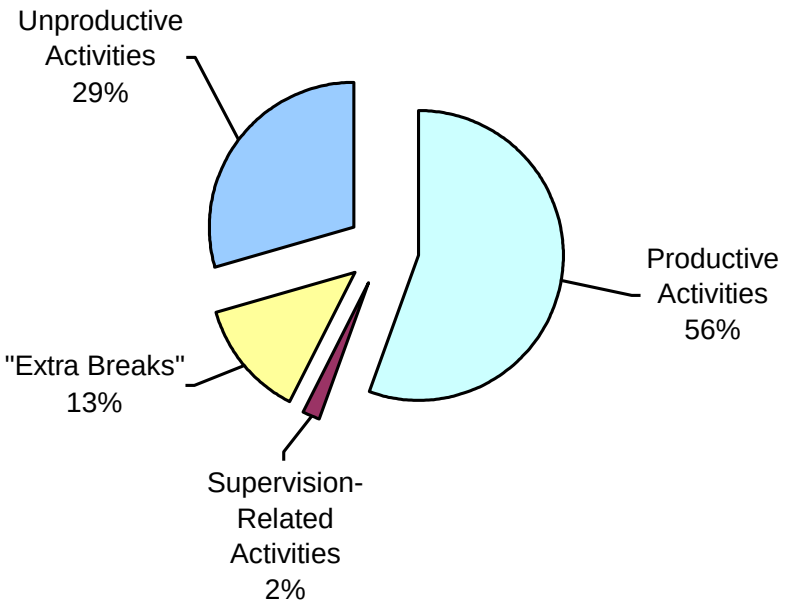


Figure 1 – Time Utilization

## Is there a problem?

The productivity issue was also illustrated by the results of a study conducted by the Industry Round Table in the distribution of a typical 10-hour construction day. Approximately 6.4 hours are spent unproductively on such activities as receiving instruction, taking breaks, searching for tools, materials and scaffolds. Of the remaining 3.6 hours spent productively, nearly half of that time was spent on rework.

In 1992, the Round Table reconvened to address productivity in the construction industry and review any progress made on the previously identified issues. Unfortunately, no improvement in productivity was apparent while the same problems were and are still evident on many major construction projects. This leads one to ask why nothing has changed and what the problem might be.

In a study in the United Kingdom[5], construction workers were requested to rate a general list of probable problems on their respective sites. Furthermore, the operatives were asked to estimate time losses per problem area and the sources of the problems. The following four tables illustrate the problems contributing to unproductive time (Tables 1 – 4).

Table 1 – Ranks of Problems Influencing Productivity

| Problem | Overall Ranking |
|---|---|
| Lack of Materials | 1 |
| Crew Interference | 2 |
| Repeat Work | 3 |
| Supervision | 4 |
| Lack of Equipment, Tools | 5 |
| Absenteeism | 6 |

Table 2 – Estimated Time loss per Problem in a 40-Hour Week

| Problem | Estimated Time Loss |
|---|---|
| Lack of Materials | 3 |
| Crew Interference | 2 |
| Repeat Work | 2.5 |
| Supervision | 2 |
| Lack of Equipment, Tools | 2 |
| Absenteeism | 0.5 |

Table 3 – Rank of Causes of Lack of Materials

| Problem | Overall Ranking |
|---|---|
| Lack of Planning | 1 |
| Transport within Site | 2 |
| Improper Materials | 3 |
| Interference | 3 |
| Unnecessary Paperwork | 5 |

Table 4 – Rank of Causes of Rework

| Problem | Estimated Time Loss |
|---|---|
| Change of Instructions | 1 |
| Unclear Instructions | 2 |
| Complex Specification | 3 |
| Poor Workmanship | 4 |

Major industrial projects in Alberta are becoming increasingly challenging, with clients' intricate requirements for complex construction, high quality products and shorter completion times. Moreover, there seems to be a never-ending stream of new equipment, materials, components and regulations, all compounded by the competitive environment compelling contractors to carry out business at low profit margins, with increased risk.

To deliver construction projects successfully, i.e. ensuring the maximum rate of production at minimum cost, a new framework and tool is needed to assist decision makers and project managers. This is one of the main focuses of this study.

This study will also assist in responding to on-site productivity problems and suggest some practical solutions towards more efficient delivery of construction projects. This study is trying to enhance and support construction owners, contractors and the Alberta Government in their desire to maintain the Alberta Advantage in the construction project environment; therefore, mitigating the trend of project cost and schedule overrun and ensuring safe construction work.

The study is an attempt to help Alberta Economic Development in its desire to partner with other concerned stakeholders to bring forward recommendations for improvements, which will help maintain and improve the Alberta Advantage in the industrial project construction.

## 1.2 Purpose of the Study

- To contribute to improving Alberta industrial projects construction performance and reduce the cost and schedule overrun.
- To help reduce the erosion of the Alberta Advantage relative to construction of major industrial resource development projects.
- To help maintain Alberta's reputation as a place to attract industry.

This study provides or proposes a tool (Section 4) that will enable managers to audit a project and determine where improvements can be made. When used in the planning phase, it might serve as a checklist to ensure successful completion of a project. The checklist by no means is a complete cookbook recipe for success but can serve as a guideline so the right questions are asked and certain minimum criteria are considered.

## 1.3 Study Objectives

The primary objective of this study was to identify the current problems causing unproductive time on Alberta industrial construction projects. This means, in addition to having an understanding of the nature of the construction workforce for effective deployment of workers, a further

understanding, which is even more important for a construction manager, involves awareness of common production problems and their relative impact on productivity. The way the authors adopted to identify productivity problems is by reviewing ten (10) industry auditing reports prepared by the authors and the University of Calgary. Based on this, a specific and detailed practical recommendation on how to improve the prevailing situation was made. The study was conducted mainly with the following objectives in mind:

1) To identify the various aspects of labour productivity including:
   - its definition and concepts, and
   - the factors affecting it.

2) To provide a "back to basics" recommendation for improving on-site good labour productivity and thereby improving the Alberta Advantage relative to construction of industrial resource development projects.

## 1.4 Scope of the Study and Methodology

Based on our recent experience and the ten (10) construction industry auditing reports, this study will:

- Identify a number of construction activities, which typically are poorly managed. Each activity is discussed and a recommendation plan for corrective action is proposed.

- Propose a tool that will enable Project Managers to audit / evaluate project performance during execution and determine where improvements can be made. The tool will be based on the following 14 major issues:

  1) Cost Management
  2) Schedule Management
  3) Work Planning
  4) Progress and Productivity
  5) Quality Management
  6) Safety Management
  7) Organization
  8) Labour Relations
  9) Materials Management
  10) Subcontract Administration
  11) Managing Construction Equipment
  12) Management of Construction Tools

13) Management of Temporary Facilities

14) Scaffolding Management

- Define a “good industry project” in terms of a system of work process or project management best practices, which produce a successful result for the stakeholder. Defining a good job at the outset of the project allows actual project performance to be measured against a previously defined baseline. This study will produce a list of major issues that define a “good job” and positively impact labour productivity.

- It is important that the definition of a good job be measurable; each component of the required performance should be explicitly stated in terms that can unambiguously be measured. Each element in each major issue will be assigned a weight within that major issue, and each major issue contributes to the overall project scope. With this understanding, a manager can then apply the framework as is or modify it to suit specific project requirements. The study will be applicable to petrochemical, power generation, and energy resource development projects. The study does not make reference to any actual failed or successful projects (or to individuals).

# 2.0 LITERATURE SEARCH

## 2.1 Introduction

Productivity has been defined in many ways. "The Concise Oxford Dictionary" (9th Edition) defines productivity as the "capacity to produce, the state of being productive; the effectiveness of productive effort, especially in the industry; production per unit of effort". Productivity by any definition or method of measurement is a comparison between input and output. It is generally expressed as[6]:

$$\text{Productivity} = \frac{\text{Output (Units of products)}}{\text{Input (Resources)}}$$

An increase in productivity means that either:

1) input is reduced for the same output, and/or

2) the quality or quantity of the output has been improved for the same input.

Productivity is the true source of competitive advantage and the key to long-term viability[6]. A company (or an economy) can increase its competitiveness through enhancing its productivity by raising the value-added content of its products and/or services faster than its competitors[7]. The concept of productivity is also increasingly linked with quality – of output, input and the process itself. An element of key importance is the quality of the workforce, its management and working conditions, and it has been generally recognized that raising productivity and improving quality of work life do tend to go hand in hand[5].

## 2.2 Productivity in the Construction Industry

There is serious disagreement about the proper definition of the term "productivity" within the construction industry. In general, the term means the output of the construction goods and services per unit of labour input. However, the meaning of "productivity" varies with its application to different areas of the construction industry. Definitions range from industry wide economic parameters to the measurement of crews and individuals. Each of these measures has its own unique purpose. Some of the commonly used definitions to measure productivity are[8]:

$$\text{Labour Productivity} = \frac{\text{Output}}{\text{Labour Cost}}$$

or

$$\text{Labour Productivity} = \frac{\text{Output}}{\text{Work Hours}}$$

In case the input is a combination of various factors, productivity is termed as Total Factor Productivity and is measured as[8]:

$$\text{Total Factor Productivity} = \frac{\text{Total Output}}{\text{Labour + Material + Equipment + Energy + Capital}}$$

Various agencies may modify the definition of productivity as per their requirements by deleting some factors and or adding other factors. For example, the American Federal Highway Administration may define productivity as[8]:

$$\text{Productivity} = \frac{\text{Output}}{\text{Design + Inspection + Construction + Right of Way}}$$

or

$$\text{Productivity} = \frac{\text{Lane Mile}}{\text{Dollars}}$$

It can be seen that there are a variety of definitions of productivity and a number of ways productivity can be measured. However, productivity or lack of it, is a major challenge facing the construction industry[3]. It is one of the most frequently discussed topics in the construction industry[9] and remains an intriguing subject and a dominating issue in construction management, promising efficient usage of resources and cost savings and ultimately affecting the bottom line of every effort in the construction process[5].

Productivity is one of the most complex issues in construction because of the interaction of management, materials, equipment, manpower, etc. – the elements that make up total on-site productivity[10, 5]. However, productivity is the most common measure of performance in the construction industry, and the clear objective must be to achieve higher productivity[1]. The reason is that productivity translates directly into cost and ultimately into contractor profits or losses[9].

Construction is a labour-intensive process. In absolute terms, manpower is the only productive resource in construction; therefore, construction productivity greatly depends upon human performance[4]. The most reliable measure of productivity is the output per man-hour achieved by the workers at the construction site, i.e. labour productivity. Labour costs typically contribute around 30% to the overall project costs, so maximizing the labour output on-site is the first area to focus attention upon in order to increase a contractor's performance and value for the money invested[1]. However, research has shown that 40 to 60% of a typical construction day is non-productive time. See Figure 2[7, 11].

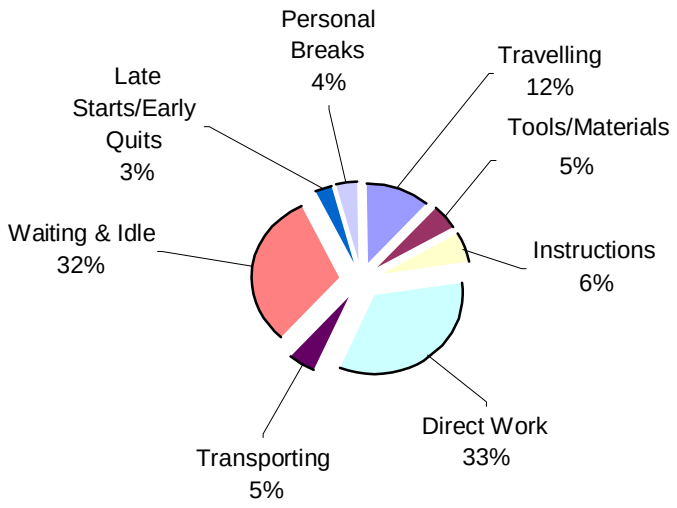


Figure 2 – Break-up of Time for Various Site Activities on a Typical Construction Day

Productivity is widely acknowledged to be a management function[12]. The Business Roundtable studies and the subsequent work of the Construction Industry Cost Effectiveness Project [Business Roundtable Report A-6] fault management for poor use of modern planning methods and are critical of owners for not acknowledging the economic payoff of planning[8]. Researchers over the years have identified a myriad of factors affecting construction productivity. These factors can be broadly classified as "external" and "internal", representing those outside the control of the firm's management and those originating within the firm, respectively. Some of the more important of the external factors include the nature of the industry, the construction client, weather, level of project development, health and safety legislation, procurement policies and codes of practices. Among the internal factors are management, technology, labour and unions[5].

In spite of the way the construction industry operates and the uniqueness of the factors associated with it, tremendous opportunity exists to improve productivity. If the construction process can be correctly identified as having 40 to 60% non-productive time, it can also be rephrased as having an opportunity to increase productivity by 40 to 60%. While it is unrealistic to believe that all the construction non-productive time can be eliminated, it is an attractive fact that a mere small increase in productivity of the order of 5 to 10% can have a significant effect on the profitability of the construction firm. The reason being is that if productivity is improved, the project duration is likely to be reduced. Therefore, a 5% increase in productivity can have the result of doubling the profits of the construction firm due to saving in direct

cost (labour cost) and indirect cost (overheads) due to decreased project duration[3].

For a construction firm, the improved labour productivity depends on a number of factors including the firm's concept of productivity, method of monitoring and measuring productivity, and programs or techniques it implements to improve productivity.

# 3.0 INDUSTRY PRACTICE

## 3.1 Summary

In this section, the authors are identifying the potential for construction productivity improvements that might be achieved for industrial projects.

The study methodology included the identification of a number of construction activities, which are typically poorly managed. Each activity is discussed and a recommendation plan for corrective action is proposed. The productivity improvement resulting from our proposed corrective action will reduce non-productive time. The “savings” are then made available to the “direct work” category.

This study concludes that a construction labour productivity improvement program represents the most significant opportunity for management. A small investment in front-end construction planning expertise can pay back by a factor of 200% or more.

Potential construction productivity savings are a direct result of better planning based on extensive hands-on knowledge of construction techniques and the inter-relationships between Engineering, Procurement and Construction. Management must commit immediately to assigning construction and constructability planning expertise to the project management team to establish the optimum construction execution plan, to establish an effective work planning system and to develop a backlog of work packages, which is the basis for a successful productivity enhancement program. Then, a continuity of ongoing audits will ensure the success of the program.

## 3.2 Methodology

The methodology used in our study to identify areas of potential construction industry productivity improvements are as follows:

a) A number of construction activities (208) were identified that typically are poorly managed or executed and have the potential for improvement. This list addresses about 80% of the activities.

b) Many of these construction activities are categorized and discussed, stating the problem and later recommending a corrective action plan. Construction activities / factors are classified into eight (8) major categories:

- Material Delivery and Control
- Constructability
- Waiting Time

- Construction Equipment
- Site Layout and Temporary Facilities
- Poor Work Planning and Utilization of Labour
- Unproductive Work
- Assumptions and Authority

c) The quantification of the savings of any productivity improvement achieved through the proposed corrective action recommendation outlined in this report is outside the scope of this study. The authors' intention is to deal with the savings issue in part 2 of this study.

## 3.3 Construction Productivity Problems

This section lists the 208 routine factors that affect labour productivity that were identified. The items that had significant impact are addressed here, but all items must be included in a plan of execution because the total impact of all the items can be significant.

The following is a list, not necessarily by category:

1. Waiting for materials at the warehouse.
2. Materials not available because paperwork is late or missing.
3. Materials not available, used by existing facilities for emergencies.
4. Materials not received, partially received, shipped incorrectly, no waste allowance.
5. Materials substituted by vendors, not reflected on drawings.
6. Materials substituted by tradesmen.
7. Materials installed incorrectly.
8. Materials lost in warehouse or laydown areas.
9. Materials lost after issued to worker.
10. Materials traded, loaned, stolen or broken.
11. Materials stored incorrectly (damaged).
12. Materials not protected after installation.
13. Materials not available (drawing revisions).
14. Materials not available (interferences).
15. Materials unable to meet quality control requirements.

16. No material bins in work areas.
17. Bins not tagged and inventoried.
18. Material not in location (no grid).
19. Material improperly tagged.
20. Material not available as delivery is late.
21. Vendor ships materials short or damaged.
22. Material never purchased (incomplete take-off).
23. Material not available (vendor ships partial order).
24. Material plan not in place (material is double handled).
25. Home office substitutions not tracked; therefore, material is not available.
26. Poor vendor fabrication quality (rework).
27. Pipe not purchased in random lengths, similar for electrical conduit.
28. Temporary facilities use permanent materials and cause later shortages.
29. Sloppy or incomplete or untrackable take-offs.
30. Constructability missing in design.
31. Standard drawings too costly to build in field.
32. Operating and start-up commissioning not considered during erection, causing rework.
33. Insulation requirements not considered during completion and commissioning. Rework, extra insulation, valves, and flanges.
34. Hydrotesting requirements not part of design rework.
35. Start-up screens, test blinds not installed as work progresses (rework).
36. Screwed pipe quality problems (rework).
37. Too much time spent using different pipe dopes and poor methods.
38. Incorrect materials and installation improved by standardization of supports, pipe nipples, 3000 vs. 6000 lb. fittings, pipe stud bolts vs. machine bolts, etc.
39. Material control system not in place.
40. Material control system in place but too late.

41. Material control system in place but not understood by team.
42. Rigging studies not done in home office; (rework,) (double handling,) (remove and reinstall.)
43. Tools not available (not purchased).
44. Tools purchased but not enough.
45. Tools broken (not repaired).
46. Tools lost, in boxes or stolen.
47. Waiting for scaffold materials, planks.
48. Waiting for someone to build scaffold.
49. Waiting for someone to check scaffold.
50. Waiting for someone to tear down scaffold.
51. Working around scaffolds left by others.
52. Construction equipment not working.
53. Construction equipment not available.
54. Construction equipment, no access.
55. Construction equipment too big or too small.
56. Construction equipment utilization.
57. Construction equipment management.
58. Construction equipment selection.
59. Tower crane vs. mobile crane. How selected.
60. “Swampers” on cranes.
61. Construction equipment maintenance during workday vs. at night.
62. Poor housekeeping, i.e. double handling garbage and debris.
63. Location of craft shacks (walking time).
64. Location of toilets (walking time).
65. Location of tool cribs (walking time).
66. Location of drinking water (walking time).
67. Location of materials (walking time).
68. Location of welding machines, pipe threaders (walking time).

69. Location of cut-off saws, benders (walking time).
70. Distribution of temporary drinking water.
71. Access to site roads cut off (walking time).
72. Poor or improper use of skilled journeymen (tool rooms, etc.).
73. Non-working union job stewards.
74. Stewards involved in hiring and firing.
75. Teamster drivers.
76. Non-essential material checking and receiving and paper generation.
77. Labour disruptions because of no pre-job mark-up jurisdiction meetings.
78. Composite crews and inefficient use of labour.
79. Poor use of apprentices and subjourneymen.
80. Accepting card members in time of shortages of skilled craftsmen.
81. Apprentices paid over the scale.
82. Improper crew mix, poor productivity and higher wages.
83. Overtime beyond scheduled work week counterproductive.
84. Poor control of place of work definition (walking time).
85. Feather bedding built into site agreement.
86. Density of workplace not considered in planning. Overmanning results.
87. Too much non-essential welder upgrading.
88. Too often welders are tested, then promoted to foremen.
89. Too much time spent on sign-up, termination, safety orientation, etc.
90. Unskilled workers not used for 40 to 50% of the work.
91. Limitation on work by apprentices.
92. Restrictions on fabrication.
93. Deliberate work slow downs, morale.
94. Crew not part of decision making.
95. Disrespect for supervisors.

96. No recognition for good work.
97. Changes received after work is complete.
98. Changes required due to field errors.
99. Changes required due to fabrication errors.
100. Design changes, operation changes.
101. Quality program not understood.
102. Specifications not available.
103. Specifications not understood.
104. Specifications not interpreted properly.
105. Compaction specification not utilized properly.
106. Too much formwork – eliminate some formwork (standardize).
107. Shutdown caused by poor safety equipment.
108. Shutdown caused by no safety equipment.
109. Shutdowns for safety violations.
110. Abuse of medical and/or facilities (no control).
111. Rental equipment not repaired, not controlled, not adequate.
112. Notes on drawings not clear – field to verify, field to check, field run should be eliminated whenever possible.
113. Inconsistent construction methods resulting in gold plating.
114. Incomplete information on engineering drawings.
115. Poor front-end or no front-end construction planning finds temporary facilities in the way of commissioning start-up, etc.
116. Temporary heating and lighting requirements not adequate, not available.
117. Heating and hoarding summer vs. winter activities not controlled.
118. No contingency plans in place for inclement weather.
119. Mobile designed welding protection not available – welding rods, rod ovens, etc.
120. No site plan for consumables, welding gases.

121. Failure to recognize and address jurisdiction conflicts results in poor morale and is not productive, i.e.:

    - Setting equipment, materials handling, small equipment operation, scaffold operation, scaffold erection, installation of supports, etc.

122. No contingency plans for foremen or general foremen absenteeism.

123. None or inadequate job descriptions for foremen, general foremen, stewards, etc.

124. Foremen and general foremen not made part of management team, double supervision.

125. No skilled instructors available after hours to train helpers and sub-journeymen in quality requirements to prevent rework and in work planning to improve safety, cost, and quality.

126. Inadequate time sheet reporting with descriptions, no accountability.

127. Field engineers not on top of quality.

128. Lack of planning has one crew in the way of another.

129. No facilities provided so foremen can be at the place of work.

130. Foremen and general foremen have no job descriptions, no interview, may not be qualified and are not appraised.

131. Foremen and general foremen have little involvement in the weekly and daily planning cost and schedule review meeting and have little commitment.

132. Positive material identification not done at source but in the field (extra cost, handling, shipping, rework, etc.).

133. Materials not delivered, everyone goes to warehouse (waiting, walking time).

134. Warehouse is located as far away as possible (walking time).

135. The camp is located as far away from the work density (walking time).

136. Rework caused by insulation thickness not considered.

137. Tolerances on quality control not established, more than adequate is then delivered.

138. Poor understanding of welding requirements (rework).

139. Lack of control of weld rod material (rework).

140. Location of weld rod ovens control (rework – walking time).

141. Radiography not up-to-date (re-scaffolding for repair).
142. Too many / few supervisors in one area.
143. Travel and subsistence as perks not used in place of long work weeks.
144. Night shift not managed and controlled.
145. Hours of work not balanced to the seasons.
146. Shift work poorly planned.
147. Elevated work and height pay not controlled.
148. Layout of temporary facilities does not consider logistics, walking time, waiting time.
149. Layout of laydown areas does not consider logistics, walking time, waiting time.
150. Temporary facilities not sized for needs. Early use of permanent facilities. No control on ongoing add-ons.
151. Tools vans not mobile (walking time).
152. Craft shacks not mobile (walking time).
153. Tool gang boxes not mobile (walking time).
154. No ongoing tool inventory or location lists posted.
155. Garbage double handled instead of bins.
156. Drinking water distributed twice daily instead of boxed water.
157. No control over broom sweeping jobsite.
158. No management of line-ups at warehouse, tool shacks, toilets, etc.
159. Temporary facilities not provided in elevated structures.
160. No deliberate checks to manage walking routes, walking time, orientation time, coffee break time, sign up time, tool in-out time, lunch break – wash up time, start time, quit time, changing time.
161. Workers not signed up at union hall when given dispatch slip.
162. No method provided for worker to communicate his problems to senior management on problems affecting his work.
163. No contingency plans in place for staff illness or absenteeism.
164. Staff turnover not planned for.
165. Qualified labourers used as janitors.

166. Start-up priorities not managed resulting in double scaffolding.

167. Material control not taught to workers.

168. Workers not motivated, no system in place that involves family, suggestion box, newspaper, rewards for cost saving methods.

169. Bad assumption that supervisors know their job, have job descriptions, are doing their job, and are effective.

170. General foremen promoted without experience.

171. Foremen promoted without experience.

172. Assumption that construction staff knows codes of practice and regulatory requirements – If not, rework.

173. No one formally checks or teaches the job requirements in all aspects to foremen and general foremen. QC, drawings, specifications.

174. Generally, no inventory of special skills once workers are on site. Recruiting still continues or poor utilization.

175. No look ahead for skilled labour results in poor utilization.

176. Most construction people do not have the skills to plan construction equipment requirements when decisions will impact site for 2-3-4 years.

177. No construction methods approved for repetitive tasks such as:

- Form building
- Scaffold erection
- Steam tracing
- Conduit supports

178. Advantage not taken to install temporary electric, grounding fire protection to permanent specifications.

179. Foremen and workers not given out “how to do” information for ready reference.

180. Quantities not reported daily. No accountability.

181. Construction quality control standards not reviewed by engineering – may be stricter than intent of specifications.

182. Assumption that subcontractors are capable.

183. Assumption that all modularization is effective.

184. Assumption that schedule must be achieved.

185. Assumption that vendors are qualified.

186. Assumption that Boilers Branch inspectors are qualified.

187. Assumption that Electrical Branch inspectors are qualified.

188. Assumption that vendor representatives are knowledgeable.

189. Assumption that OH&S inspectors are qualified, for all unique situations.

190. Assumption that Owner representatives are qualified.

191. Contingency plans for supervisory vacations and/or turnover missing causing disruption to work force.

192. Excessive fine tuning, i.e. grinding welds, grinding, tank welding, etc.

193. Work packaging not done, not done in detail, not understood.

194. No formal way of identifying information flow, late information flow, information not trackable.

195. No formal distribution of project documentation.

196. Personal breaks not monitored – coffee breaks, etc.

197. Constructability – access to steel bolted connections vs. welded connection.

198. Improper crew mix.

199. Constructability not done or too late, i.e. durion pipe costs 30% more for labour than other acceptable alternatives.

200. Non-standardization of tubing bends for steam tracing valves and flanges, have bends made outside.

201. Constructability – no formal cost impact studies with alternatives for late design changes.

202. No formal control of survey crews (job creation).

203. No formal meetings for cost schedule reviews and accountability.

204. No independent eyes looking at construction methods improvement.

205. Manpower mobilized before plans are in place.

206. Breaks to do accounting/pick-up drawings, specifications.

207. Due to lack of work packages, foremen spend time on equipment – searching – trying to do re-engineering, figuring what is required (i.e. engineering), trying to sort out what is required.

208. Modularization facility assumed to be more efficient and productive but has most of the productivity problems, rework problems that are found on jobsite; failure to recognize plan, organize, control, manage, audit the facility.

## 3.4 Assessment of Productivity Improvement Potential

In this section, the authors provided an assessment of the productivity problems (identified in Section 3.3) and recommendations for improvement. These problems and recommendations are presented in eight groups as follows:

- Material Delivery and Control
- Constructability
- Waiting Time
- Construction Equipment
- Site Layout and Temporary Facilities
- Poor Work Planning and Utilization of Labour
- Unproductive Work
- Assumptions and Authority

### 3.4.1 Material Delivery and Control

Items addressed from Section 3.3, Construction Productivity Problems:

- (37) (38) (42)

37. Too much time spent using different pipe dopes and poor methods.

    Normally, as many as 8 grades of pipe dopes are specified for stud bolts. In many cases, the pipe fitters do not bother to use any or they use their favourite one (i.e. the one they have at hand). If no dope is used the threads generally seize up and are cut and thrown away. When a pipe dope is used in the field, a pipe fitter will paint each bolt with a small brush spending at least 15 minutes per set. If it is wrong, he will later remove them all, ruin the gasket and redo them.

Recommendation

Even though the best dope is expensive, it should be used. It should be either specified to the bolt supplier or at least done off site. Bolts, once doped, can be thrown on the ground (usual case) and will not seize up. Savings here will be substantial.

38. Incorrect materials and installation improved by standardization of supports, pipe nipples, 3000 vs. 6000 lb. fittings, pipe stud bolts vs. machine bolts, etc.

Historically, rework results in the improper use of small fittings or improper substitution.

Recommendation

To prevent the wrong use of 3000# for 6000# fittings and the use of schedule 80 nipples for schedule 160, it is recommended that the higher spec only be used. This would not only prevent the associated rework, but also would eliminate the many items being followed through the material control system. The incremental cost of the fittings would not make much difference. All machine bolts used in piping systems should be converted to stud bolts for the same reason.

42. Rigging studies not done in home office; rework, double handling, remove and reinstall.

Rigging Studies and rigging equipment requirements are generally left up to the construction personnel and as a result, much time is lost at the worker level when trying to figure out the centre of gravity of odd shapes such as pipe spools, etc. In addition, most major equipment has lifting lugs provided by the vendor, but these are not always compatible with the rigging attachments found in the field.

Recommendation

Piping designers should ensure the centre of gravity is marked on the spools as they are shown on the isometrics. The field personnel in an average 5-man crew will do this by trial and error and can waste as much as ½ hour x 5 men per spool(s). As far as lifting lugs on equipment is concerned, the designers should indicate what they had in mind. This would also save many hours.

There can be no doubt that Material Control done poorly influences productivity. Material Control is an area that most engineering and construction contractors do poorly. This starts with poor definition.

The following represent some of the many factors that have an impact on waiting time, walking time, rework, etc.

- The design office starts by assigning staff to make bulk take-offs. At best, they take off 80% of the items and 70 to 80% of the dollars.
- Vendors make substitutions that are not properly tracked.
- Fabricators make improper substitutions.
- The field forces store the material improperly.
- The field forces mark the material improperly.
- The field forces use the materials for other than intended use.
- The workers install the materials wrong. The field forces do not control materials once issued.

Recommendation

Ensure that adequate procedures and qualified personnel are assigned every step of the way. This can be done by interviews and by having qualified personnel do audits to ensure things are working.

First, two separate and independent groups should do the material take-offs. The results (done in the same format) and the differences must be reconciled. This method will ensure the accuracy of the take-offs. All revisions to P&ID, orthographic drawings, line tables and isometrics must be checked for additional materials and surpluses. Requisitions and purchase orders must be checked by line item back to the take-offs to ensure nothing is missed.

If vendor substitutions are made and approved by engineering at the front-end, then the individual specifications must be changed to allow for these substitutions as the material may actually be needed months or even years later.

The warehouse and laydown areas must have a grid system to ensure the receiving documentation identifies where the material has been stored. This is important both in the field and in remote locations. All material identification colour codes and tags must be verified at the time of receipt as improperly tagged or wrong colour codes will indicate material is not available. Once material is identified properly, it must be stored properly. When material is withdrawn for modules, pre-assembly or field erection, it is important that shortages (identified as needed but not shown) get ordered and tracked within the system. At this point, it is important to discuss bin leveling and having some of the most common items available in bins at the work site.

This factor allows the supervisor to have ready access to those items that are low cost and prevents waiting or walking time.

Materials should be bagged, checked and delivered to the work areas. Workers should not always travel in pairs and both should go to the warehouse to wait for the materials if not delivered. Thought should be given to how things are stored. They should be stored so that minimum walking time is the order for the day. For example, if spools are stored in one area, valves and supports in another and small items are in yet another, then it stands to reason that all sites and locations will be visited each time materials are needed. No work should be assigned unless all the materials are proven to be available. When materials are bagged and tagged for an operation, shortages for many reasons should be reconciled prior to issue. This will prevent the work crews from installing and leaving partial installations.

Partial shipments must be tracked and expedited. A couple of hundred small fittings not received could have an influence on a couple of hundred installations.

Damaged materials must be checked and replaced as soon as they are discovered because sooner or later they will not be available and result in partial installations. The reason that partial installations are so significant is because the men, equipment, tools, welding rods, welding heads and scaffolding must all be moved to the work area every time something is installed. These actions far outweigh the physical act of installing the items. By ensuring the installation is complete, we can expect to save 50% of the cost.

It is important to have a discussion about the proper sequence of work. Historically, construction crews installed isometrics one at a time. They would go all over the plant installing scaffold, hauling their tools and equipment as they go. Generally they would come back to the same area several times; once to install the large spools, back to install the supports, back to install the small pipe, back to install the tracing, etc. In order to avoid moving in and out at least four to six times, we should have work packages put together for small areas. All the work in the small area should be given to a crew. All materials should be available before work is begun. This single item, if done properly, could reduce movement and re-setup time, saving many hours. If the progress of the crew and the quality of the installation is not complete at the end of a shift, the materials can be properly stored to ensure they are available when the crew returns.

Once piping and other activities get underway, the field engineers and supervisors can never keep up. They follow the crews all over the jobsite trying to find the missing items, etc. To prevent this it is very important to have a minimum of two weeks work available for each geographical area prior to bringing on and assigning the work crews. The work packages should be

identified, pre-bagged, colour coded to a small geographical area and delivered to the work area in advance of the crews starting. Tools, consumables, scaffolding, weld rod and leads must be ready when the crew starts. If the work is handled in this manner the savings will be significant.

Once the installation gets underway and revised drawings are received, they should not be just sent out for installation. The revisions should be packaged and given to separate crews. This separate crew can have meaningful work and the entire site is not interrupted. Temporary piping installations should be handled in the same way as revisions. When permanent materials are used for temporary installations and bagged and controlled, it is easy to reorder the materials.

Since field engineers spend up to 70% of their time fighting material problems, much of this time can be put to use in the assembly of packages complete with drawings specs, requirements, tracing, hydrotest information, etc. This method can reduce the staff requirement by as much as 20%. While tools are mentioned elsewhere, it is worth mentioning that their sizes, types, etc. must be included in the work package.

### 3.4.2 Constructability

Items addressed from Section 3.3, Construction Productivity Problems:

- (27) (30 – 36) (105) (106) (201)

27. Pipe not purchased in random lengths, similar for electrical conduit.

    Historically, procurement personnel did not consider the importance of purchasing pipe in double random lengths. The cost per meter is generally the same, but we can eliminate a weld and the x-ray, etc. This cost in the field is substantial when we consider the weld (average size 6") takes about 4 hours. The x-ray costs $200, the repairs (5%), the re-weld, the extra scaffold, etc. Conduit comes in 10-foot lengths and can be made in 20-foot lengths. Recognizing sizeable orders are required, then manufacturers will run 20-foot lengths.

    Recommendation

    Recommend double random pipe and 20 foot conduit runs.

30. Constructability missing in design.

    Most management personnel agree that the greatest opportunity to influence the final cost is in the front-end of a project.

Bringing construction technology, i.e. meshing construction know-how and up to date construction technology into engineering, brings a return of 10 or 20 times the cost.

Historically, most design engineers were not familiar with union jurisdiction problems caused by using different terminology for different components. Calling a furnace tube a downcomer will certainly cause a problem between ironworkers and boilermakers. This sort of thing would be eliminated if a skilled construction person were part of the design team.

The prime role of the constructability person would be to review all the project documents while they are in the formulation stage, not when they are ready for issue.

On a job the size of Mega projects more than one person would be required. This role, if carefully planned and understood by the team, would quickly start paying dividends.

Recommendation

Recommend Owner insist on constructability review.

31. Standard drawings too costly to build in field.

There should be a review of pipe supports, shoes, guides, instrument stands, etc.

Historically, this activity is not done and results in extra welding, installation of the wrong materials and field fabrication, etc.

On similar projects, shoes and supports, once reviewed and reworked, were found to eliminate as much as 50% of the welding manhours, which are always in short supply and cut down on the individual pieces thus reducing the opportunity for mistakes, etc.

Recommendation

Recommend standardization of supports.

32. Operating and start-up commissioning not considered during erection, causing rework.

Steam and Condensate Blowdowns

Generally, during detail design the requirements for start-up are missed. An example of this is the steam and condensate line blowdowns. Consideration should be given to the fact that this is an operation that will take place while the workers are still in camp and

goes on 24 hours a day. The spools and supports, etc. are generally left up to the field and are all fabricated with premium dollars.

Recommendation

This activity should become part of the detail design and spools, etc., get fabricated off site and form part of normal construction installation activity.

33. Insulation requirements not considered during completion and commissioning. Rework, extra insulation, valves, and flanges.

Presently, insulation of flanges, valves, control valves, etc. is something that comes very late in the project. Insulation of these items happens several times prior to start-up and the repeated operation results in a loss of productivity and extremely high costs. Insulation is removed several times during start-up and commissioning.

Recommendation

A thorough review of the P&IDs should clearly indicate the items that require insulation. Blankets should be pre-ordered with proper tag numbers and left off until the system is turned over to operations. A small, dedicated maintenance crew could install these blankets once after the system is ready to be energized. This activity could reduce construction activity and provide a source of local employment to fabricate tags and catalogue the blankets by system.

34. Hydrotesting requirements not part of design rework.

During the design phase, when isometrics are produced, no consideration is generally given to hydrotesting, as this is left to the field. When the field gets around to developing hydrotest diagrams, the piping systems are well along (say 70 to 80% complete). At this point, flanges at equipment are broken, gaskets are thrown away and test blinds are installed with new gaskets by the test crew. If we were to look closely at this item for one line, it would be as follows:

- Build a scaffold and install the spool off a piece of equipment with bolts and gaskets generally at 2 ends. Cost would be: 4 hours x 2 men for scaffold time x 2 ends = 16 hours total.

- Installation at 2 ends: 2 men x 4 hours x 2 ends = 16 hours total.

- Remove scaffold at 2 ends: 2 men x 2 hours x 2 ends = 8 hours total.

- Build scaffold for 2 test blinds weeks later: 4 hours x 2 men x 2 ends = 16 hours.

- Install 2 test blinds 2 men = 2 hours total = 18 hours

Recommendation

Now if test blinds were installed as we went along, we could save the 18 hours plus 2 gaskets and install the correct length bolts. 1,000 hydrotests savings would be 1,000 x 18 or 18,000 hrs.

35. Start-up screens, test blinds not installed as work progresses (rework).

Commissioning and hydrotest requirements are not planned and identified during the design phase but are left to the construction team to plan in the field. This results is substantial rework and a waste of material when bolted up connections are opened to install screens and blinds, damaging gaskets, bolts, etc.

Recommendation

Orthographic and isometric drawings should identify the need for and locations of screens and test blinds. The bill of materials should include screens, blinds, longer bolts, replacement gaskets, which should be bagged with the iso and installed during initial construction.

Start-up and hydrotest plans should identify the material needed for final bolt up (i.e. correct size bolts, gaskets, etc.)

This item would save scaffolding twice for elevated flanges and approximately 4 hours per blind. Blinds on the other hand cost $4/kg; in addition, the trend would save one gasket for every blind. The initial gasket could be of low-grade material thereby saving the material cost of two expensive gaskets.

Note: Most bolts are ordered too short to accommodate hydrotest blinds. If all bolts were ordered just ¼' longer, they would save having double bolts.

36. Screwed pipe quality problems (rework).

(Pre Fabricated Socket Weld Pipe Versus Screwed Pipe)

On larger projects, screwed piping systems are generally field run. Experience indicates that this is a bad decision for several reasons. First, only very skilled people can make a screwed joint so it will pass a hydrotest. Typically systems are put together by inexperienced personnel and have to be 100% reworked, even if the threads are made properly. They are generally not installed correctly.

Recommendation

A study on a major construction project indicated that socket welded pipe could be substituted for screwed pipe and that socket welded pipe could be fabricated off site and handled properly, identified properly, unloaded and stored properly, thus reducing the rework of screwed systems plus realizing the savings and off site work, with the dollar differential and increased shop productivity. Here one should be careful not to give in to temptations or pressure to have all small bore pipe fabricated in the field.

105. Compaction specification not utilized properly.

When a site is leveled and brought to grade, compaction costs are extremely high and much of it not required, or certainly not to the degree of the standard specifications.

If we had a time lapse camera, we would see the site leveled and compacted, dug up for underground drains and sewers and compacted, dug up for foundations sitting on piles and compacted, dug up for electrical wire and grounding and compacted. Bad enough, when the on plot areas are dug up and compacted several times, but in off plot areas, it is wasteful to compact ditches 15 and 20 feet deep when compaction to the top of the pipe would have been enough.

Recommendation

To avoid this type of problem, the construction manager assigned to the design team must question every specification and get specific requirements understood during design stage, otherwise needless dollars will be spent.

106. Too much formwork – eliminate some formwork (standardize).

Historically, design companies do not review their common standard drawings.

Recommendation

Foundation designs for pumps, vessels, exchanger, piperacks, etc. could all be reviewed and standardized to use standard form panels, standard anchor bolts, standard reinforcing steel, etc. These could then in turn be fabricated off site in an assembly line production at a productivity and off site dollar savings. This could result in at least 20% savings in labour and overall savings of at least 5% of foundation account.

201. Constructability – no formal cost impact studies with alternatives for late design changes.

Historically, late design changes are made with no regard to the implications of the change on field installation costs. For instance, a decision made in the home office to add a pipe support at the top of a tower or vessel may be made after the tower has been erected and scaffolding removed. To install the $10 pipe support, new scaffolding (erection and dismantling) will be required for elevated work and a special installation crew will need to be organized to weld the support in place. Typically, this type of late design change is very expensive to install.

Recommendation

A constructability expert in the home office should review all changes to determine whether the design considers the most effective construction installation impacts. A small investment in effort can result in substantial savings.

In the example above, a support at ground level might be satisfactory, eliminating the need for scaffolding.

### 3.4.3 Waiting Time

Items addressed from Section 3.3, Construction Productivity Problems:

- (43 – 51) (70) (86)

43. Tools not available; not purchased.

44. Tools purchased but not enough.

45. Tools broken; not repaired.

46. Tools lost, in boxes or stolen.

On cost reimbursable projects, owners give the contractor a percentage of direct labour to allow for tools and consumables. Some contractors on the other hand do not have a good system to identify what tools they will need and what consumables they require. Normally, men assigned to the work cannot find the proper tools and either borrow the tools, fix the tools or are reassigned to some other job. The contractor, once he knows he does not have the tools, will generally purchase the requirement, but this cycle will continue until the new tools are received. The owner pays for all this waiting time, walking time or repair time, which far exceeds the percentage given to the contractor.

Recommendation

The owner should consider purchasing the tools on a reimbursable basis and should hold the contractor responsible. When work is issued, the contractor should spell out what is required and be satisfied that the tools are in inventory before issuing the work. Periodic inventories during days off are required from time to time (monthly) to ensure the inventory is up to speed. If good tool control and issue is in place, a savings on waiting time, walking time and reassignment would be realized of at least 25 to 50%. If the contractor would go as far as putting the sizes on the work package, this would prevent the worker from going all the way up a tower measuring the bolts on a manway, then going to the tool crib to get the correct size of tool.

47. Waiting for scaffold materials, planks.

48. Waiting for someone to build scaffold.

49. Waiting for someone to check scaffold.

50. Waiting for someone to tear down scaffold.

51. Working around scaffolds left by others.

Scaffolding is a major problem on all construction jobs. This single item is a major cause of waiting time and even after it is built, it may not be safe and must be rebuilt.

Recommendation

The following recommendations cover the planning, control, building, etc. for scaffolding.

Firstly, sample scaffolds should be built with identifying tags indicating what a safe acceptable scaffold looks like. Crews should see this, and this standard should be checked as scaffold builders are being trained or as the work progresses. Enough early attention will prevent rework later. Since the majority of scaffolds take 4 hours to erect, it must be acceptable once built. Scaffolds should be built in advance of the work being assigned to a crew, as 4 men can wait up to 4 hours if it is not ready. The scaffolding requirements should be planned on drawings and accountability for requirements, timing, etc. should be known. Some scaffolds are built in 4 hours for one crew and are taken down and rebuilt several times for different crews or different operations. Some are left in place for weeks and months contributing to congestion and a lack of space required for access.

Scaffolds should have tags for the week they were erected. A planner should identify what needs to be done prior to removal, what crafts will

need the scaffold and when it should be taken down. Follow-up is required to ensure all this takes place.

A proper scaffold control plan could cut the scaffold hours by 50%.

70. Distribution of temporary drinking water.

On most projects this item just happens. A source of drinking water is identified, 5-gallon cans are washed daily and sterilized and trucks, driver and labourers for distribution come in on premium time to ensure water is distributed throughout the site. Generally, 1 can for every 20 workers. Cranes (with operators) are used to distribute the water to elevated structures and generally fresh water is provided twice per shift. On a jobsite with a peak manpower of 3000 workers, this activity becomes a full time job for 2 or 3 years for a 6 to 10 man crew.

Recommendation

This item could easily be reduced by 50% by having a local service company provide coolers with disposable water cartons. This item could also be a source of employment for local workers.

86. Density of workplace not considered in planning. Overmanning results.

Generally, when schedules are put together, they represent quantities multiplied by some manhour rate equaling total manhours for a given area. As the work gets underway and all the equipment tools, scaffolding, welding machines, plus permanent plant equipment are included in a work place, there becomes a limit to how many men can cover the work within the original schedule duration. The tendency then is to overman the work place resulting in reduced productivity.

Recommendation

When the original plan is put together, it is important to allocate only 150 to 200 square feet per man. If the schedule time frame is to be shortened, it must be by doing some pre-assembly or other method to ensure the density is not exceeded.

### 3.4.4 Construction Equipment

Items addressed from Section 3.3, Construction Productivity Problems:

- (52 – 58) (61) (176)

52. Construction equipment not working.

53. Construction equipment not available.

54. Construction equipment, no access.

55. Construction equipment too big – too small.

56. Construction equipment utilization.

57. Construction equipment management.

58. Construction equipment selection.

61. Construction equipment maintenance during workday vs. at night.

176. Most construction people do not have the skills to plan construction equipment requirements when decisions will impact site for 2-3-4 years.

Most construction people do not have the skills to plan construction equipment requirements, especially when these decisions will have an impact on the site for 2-3-4 years through substantially different conditions during mobilization, peak construction and wind-down.

In the absence of good construction planning, typically there is substantially more construction equipment on site, particularly cherry pickers and heavy cranes, which often lie unused or underutilized while providing a "contingency" for poor planning, i.e. have enough.

Recommendation

We have recommended a minimum of two weeks of construction work packages available at all times. Included in the work packages should be lifting or major equipment requirements, which can be scheduled in the weekly work plans or 30 or 90 day look aheads for special equipment. In this way, allocation of equipment can be managed to minimize total equipment needs and maximize utilization of available equipment.

With effective planning, work packages can be scheduled to maximize the utilization of equipment in a specific area, to minimize equipment

movement on sites or to complete all small lifts in an area before access to a location is blocked off by construction progress. Construction planning to justify the economics of a tower crane versus mobile cranes can affect cost savings and eliminate on-ground congestion.

Poor management and control of equipment is costly. Inefficient monitoring of equipment demand results in excessive equipment with associated costs. Inability to track damaged or non-working equipment means poor utilization and extra waiting time for work crews when equipment is not available.

Construction equipment can be maintained and repaired during the night shift so that standby time for equipment and labour during the dayshift is minimized. Standardization of equipment, where possible, will improve maintenance productivity and reduce spare part inventory.

It is important to have an effective mix of equipment sizes. Using larger equipment than necessary "because it is there" is not economically sound. Hourly and standby rates are more expensive than correctly sized, smaller equipment. Better planning would reduce the amount of equipment on standby and would ensure the right sized (and cost) equipment is allocated for the work.

Planning and scheduling of construction work must make allowances for equipment access for delayed or long lead items that get blocked off as construction progresses. Planning work out of sequence (early) to complete work in an area that will be blocked off can lead to larger savings compared to the need for long boom cranes. Where long boom equipment is needed for key work, planning or rescheduling, adjacent work packages to make better utilization of large equipment may offer savings.

Typically, construction equipment is very poorly managed resulting in poor utilization. Better planning could achieve a substantial cost saving. Therefore, it is important not to just measure daily quantities and labour hours, but even if equipment is job owned, to set an hourly value to let people know the cost of utilization.

### 3.4.5 Site Layout and Temporary Facilities

Items addressed from Section 3.3, Construction Productivity Problems:

- (63 – 69) (151 – 154)

63. Location of craft shacks (walking time).

64. Location of toilets (walking time).

65. Location of tool cribs (walking time).

66. Location of drinking water (walking time).

67. Location of materials (walking time).

68. Location of welding machines, pipe threaders (walking time).

69. Location of cut-off saws, benders (walking time).

151. Tools vans not mobile (walking time).

152. Craft shacks not mobile (walking time).

153. Tool gang boxes not mobile (walking time).

154. No ongoing tool inventory or location lists posted.

Typically, the location of temporary facilities is decided upon during site mobilizations and major facilities (camp, laydown yard, main warehouse) are located far from dense work areas. Once located, temporary facilities tend not to move, despite changes in location and density of the work areas.

Recommendation

Ideally, craft shacks, toilets, tool cribs, material storerooms, etc., should be located as close to the work as possible to minimize walking time. Welding machines, pipe threaders, cut off saws and benders should also be located close to the work to reduce walking time. There should be enough of this common equipment to ensure there are no lineups of workers wasting time, waiting for equipment to be free.

In a typical day, workers spend about 10% of their working day walking (to and from camp and worksite, to craft shacks, toilet, tool cribs, warehouse and laydown yard).

The location of temporary facilities should be continually reviewed to ensure that they are located close to current work. Craft shacks, tool cribs, toilets and material warehouses should be designed as mobile facilities to permit their easy movement around the site.

Satellite tool cribs and material warehouses should be located close to the work and stocked with tools and materials that support the current work activities. The weekly work plan should identify extra or special tools, consumable materials and equipment that can be stocked in the satellite mobile facilities.

Inventories of toolboxes and tool cribs should be made periodically to ensure that the tools are available and they should be restocked as required. This will reduce travel time and waiting time to the tool cribs or to borrow equipment from other workers.

Consideration should be given to the location of toilets on each level of multi-level buildings to reduce travel time.

Small tools should be constantly reviewed to ensure they are in good working order and repaired or replaced as required. Consideration should be given to purchasing more tools than would typically be supplied (i.e. contractors % for tools to allow for loss, damage or peak demand). Waiting time for crew can quickly exceed cost of additional equipment.

Walking or travelling time can account for 10% of the working day. Better planning of temporary facilities and constant review can achieve a 50% reduction in travel time.

### 3.4.6 Poor Work Planning and Utilization of Labour

Items addressed from Section 3.3, Construction Productivity Problems:

- (72) (74) (75) (78) (79) (81) (82) (90) (91) (125) (159) (160) (174) (175) (178) (180) (192) (193)

72. Poor or improper use of skilled journeymen (tool rooms, etc.).

74. Stewards involved in hiring and firing.

75. Teamster drivers.

78. Composite crews and inefficient use of labour.

79. Poor use of apprentices and subjourneymen.

81. Apprentices paid over the scale.

82. Improper crew mix, poor productivity and more wages.

90. Unskilled workers not used for 40 to 50% of the work.

91. Limitation on work by apprentices.

Poor work planning results in poor utilization of labour and supervision. Inability to plan effectively limits opportunities to utilize cost-effective crew mixes and achieving labour account cost reduction by using less high cost journeymen. On average, a journeyman costs 30% more than unskilled helpers.

Construction round table estimates that 40 to 50% of all construction work can be done by unskilled helpers. However, because the labour ordering and allocation process is typically poorly managed, decisions on supply of labour, by default, are made by the union hall, which supplies journeymen.

Unions will allow the contractor to manage the labour component of the work. Management must plan the work specifically enough to identify opportunities for increased use of unskilled labour and far enough in advance to arrange for the supply of unskilled and skilled labour.

<u>Recommendation</u>

Before any labour comes on site, the management team should plan at least 3 weeks work in advance and to a level of detail that identifies and tracks each individual labourer by craft and experience level. This advance planning should continue throughout the job.

A published strategy of maximizing the use of helpers, apprentices and sub-journeymen should be provided to the unions as the project labour plan. The plan should address ratios for foremen and supervisors including the use of working foremen.

Rigorous monitoring of wage rates will ensure that apprentices are not paid over scale and that the full potential for cost savings due to cost differential between unskilled and journeymen labour are fully realized.

Overall, an effective labour force planning effort, utilizing a cost effective crew mix strategy can achieve a labour cost saving of 20%.

125. No skilled instructors available after hours to train helpers and sub-journeymen in quality requirements to prevent rework and in work planning to improve safety, cost, and quality.

While it is difficult to start off on a project and get everyone on the same band wagon as far as cost, schedule, safety and quality are concerned, it is a lot easier once the job is underway to take the proven systems and requirements and to make these available to the apprentices and helpers. Unfortunately, it is difficult to find qualified instructors to ensure the procedures, etc. are not only understood by the workers but can also be implemented.

Recommendation

The recommendation is to have all the methods and teaching materials, etc. in such a shape that if instructors can be found, they will not have to spend their time putting materials together.

159. Temporary facilities not provided in elevated structures.

People working in elevated structures must climb down to ground level to get water, use toilets, get access to tool cribs, rod ovens, run connections from welding machines, etc. and then climb back to the work place. Limited and congested stairways or elevators increase delays and time away from productive work. In dense, high elevation work areas, this is a major cause of non-productive time.

Recommendation

Even if space is at a premium in high density elevated work spaces, consideration should be given to providing some basic services at various levels in the structure (i.e. drinking water supply, toilets, tool cribs, welding machines, lunch rooms/change shacks, etc.).

160. No deliberate checks to manage walking routes, walking time, orientation time, coffee break time, sign up time, tool in-out time, lunch break – wash up time, start time, quit time, changing time.

Starts, quits and breaks account for 11% of the workers time. The bulk of this break time offers little chance of being reduced. However, our analysis indicates a potential to “save” 1.9% from the S, Q & B category. While it may not seem to be a lot, on a project management budget of 17 million manhours, a 1.9% saving would equal over 320,000 manhours, which, at $80.00 per hour, represents a saving of almost $26 million.

Recommendation

Bring in a construction expert early in the project to establish an efficient construction plan, including the layout of temporary facilities and to establish project procedures relating to breaks, sign on procedures, etc. However, the initial plan will not be enough. The plan must be continually updated to reflect labour peaks, summer/winter work, job progress across the site, etc.

Typically, this aspect of the work is poorly managed or dismissed as only "a couple of minutes here or there". Yet the dollar value of potential savings demands that the issue be managed effectively on an ongoing basis.

A small investment of effort can result in a major savings.

174. Generally, no inventory of special skills once workers are on site. Recruiting still continues or poor utilization.

175. No look ahead for skilled labour results in poor utilization.

The labour ordering and allocation process identifies labour needs by category for immediate or short-term needs. The union hall or recruitment office provides workers to meet the current need. Once the initial job is completed, the worker moves on to the next job that his crew is given and no record of the whereabouts or particular skills of the individual worker are made.

Also, staff requirements for craftsmen tend to be poorly managed, if managed at all. Poor planning and the inability to look beyond the most immediate job, means that special jobs requiring unique skills do not get the skilled labour needed to complete the work efficiently. Installation is handled by whoever is available, resulting in expensive re-work. Specialized work requires special materials. Re-work caused by improper skill levels of labour often results in wastage of parts and consumables, which typically are not stocked and require long delivery times for replacement parts, resulting in delays.

Also, expensive recruitment for special skills can occur even when the skill is available on site but not tracked.

Recommendation

Design a craft and non-manual inventory tracking system that identifies special skill capabilities. Correlate to timesheet/payroll system so that key craftsmen and non-manual are tracked on the job.

Direct foremen, superintendents and field engineers to look for and report good hands for future reference and input to the inventory system.

As part of the development of a three-week backlog of available work, work packages should identify any special skill requirements and draw on the inventory to identify and commit key personnel to the work order. This process will also identify if the required skill is not on site and can start the required recruitment. Work packages requiring special labour or supervision should not be released for construction until skills are in place.

Using an effective "look-ahead" work planning system can provide an opportunity to reward good workers by providing them with the opportunity to work on more challenging work. This not only builds morale, but also, by definition, will result in less re-work by having the best people assigned to work that historically gives the most problems.

178. Advantage not taken to install temporary electric, grounding fire protection to permanent specifications.

Temporary facilities are quickly installed to meet initial start-up requirements. Facilities and services are not usually installed to meet existing codes because they are expected to be taken out once permanent facilities are installed. The facilities are put in place and subsequently removed at substantial cost, but no attempt is made to look for alternate permanent uses of the facilities.

Recommendation

During early construction input to the EPC plan, investigate the opportunities for permanent application for temporary facilities. For example, the main water collection/distribution ring around the battery limits may have use as a main header for the permanent plant. If this potential exists, the "temporary" facility can be installed to then meet the full permanent use specification, offering the potential for significant savings.

Also, where the potential exists for re-use, all grounding, insulation, fire protection, etc. to meet permanent specifications should be incorporated during the initial installation.

180. Quantities not reported daily. No accountability.

Quantities are reported by the field engineer, who makes periodic checks of installed quantities and reports on a percentage-complete basis. However, typically the field engineer is overwhelmed with the

need to track missing drawings and materials or engineering work in the field to track and report installed quantities.

As a result, critical information for progress and performance monitoring, scheduling and project control are lacking or late. This makes it difficult for management to assess where they are in the job, limits their ability to plan current work and their ability to look ahead to future work due to the poor quality "base" information.

Recommendation

Consider staffing a small crew dedicated to reporting installed quantities and coordinating between the engineer and the foreman.

An effective work planning system will incorporate a reporting feedback component. The "ready for construction" work order should be returned and signed off by the foreman/engineer when complete and before the new package is issued. Quantities identified on the completed work order can be taken off and recorded as installed work.

The small expenditure for the quantity reporting crew will pay dividends in current, correct information for planning purposes and will free up time, which the engineer and foreman can dedicate to providing hands-on direction to the crews.

192. Excessive fine-tuning, i.e. grinding welds, grinding tank welding, etc.

Welders and foremen do not differentiate between different types of work. Because the procedure says to grind welds, grinding takes place to a perfectly smooth base even if not required. Internal and external welds on tanks are ground smooth, even though there is not need for it. If you consider the volume of welds to be ground on a major tank farm, the waste of expensive welder time is staggering.

Recommendation

Review welding procedures before the project goes to the field. Determine what the project policy will be with respect to grinding. Produce a procedure that specifically minimize grinding, where approved, and direct foremen to ensure the procedure is followed.

Include instruction on grinding requirements, where applicable, in work order package directions.

193. Work packaging not done, not done in detail, not understood.

Due to poor planning, work orders are issued for construction without all required information and materials available to the crew. Out-of-

date drawings, equipment or material not available, pre-requisite work not completed and other coordination problems result in wasted time, incomplete or incorrect work, excessive cost and poor morale.

### 3.4.7 Unproductive Work

Items addressed from Section 3.3, Construction Productivity Problems:

- (60) (62) (71) (75 –77) (80) (83 –85) (87 –89) (92 – 104) (107 – 122) (135) (136 – 150) (155 – 159) (161 – 166) (168 – 173) (177) (179) (195 – 200) (202 – 207)

60. "Swampers" on cranes.

The problem here is that over the years people would get assigned to walk beside or behind (or both) a crane or cherry picker to make sure it did not back into or run over someone or something. Generally, these people were only assigned to the rig when it was moving. As time went on these people became assigned full time to the rig even when it was parked in one spot for weeks or months. These "swampers" were never assigned any real work, and the cost of waiting around for the crane to travel was included in the cost of the work being performed, thus driving up the unit rate and costing the project productivity losses beyond anything reasonable.

Recommendation

To eliminate this problem, swampers should not be assigned to rigs, they should come from the crew doing the job. This poor practice can be drastically reduced, and the savings will go to direct productive work thus improving overall productivity.

62. Poor housekeeping, i.e. double handling garbage and debris.

On most sites (and sites within large projects) there is no plan for handling garbage or debris. It generally just happens. Crews drive around and haul materials to some designated site every day from the beginning of the job until the last day. Within the site area, the debris made by one worker is moved by another or swept around by even another worker. Materials can be moved three or more times within the area and finally make their way to an area pile, which is loaded and hauled away.

Recommendation

For a Mega construction job, this sort of thing can be eliminated by two recommendations:

First, dumpsters must be of ample quantity and located so that they are within easy reach of the worker otherwise he won't use them.

Second, each worker must be instructed that it is his job to clean up after himself and no labourers should be provided.

With instruction and close monitoring, this item could be reduced significantly.

If clean up was handled as above, we could expect to save several million dollars over the life of Mega construction projects. The capital cost would give Operations a base of equipment for their use after construction took advantage of the savings.

The savings here could be several million dollars.

71. Access to site roads cut off (walking time).

On most sites the access roads are few and are generally available, but the larger the project, the more activity that starts interfering with access roads around the plant. If 2,000 or 3,0000 men have to walk around holes or barricades, plus find alternative routes for equipment and deliveries, it does not take long to see a significant cost caused by poor or disrupted access.

Recommendation

The recommendation here is to have a site drawing indicating where the dense pockets of labour are working and indicating their routes to and from the site. Alternate plans to cut roads, ditches, etc. should only be made when other acceptable routes are ready.

Even though this does not seem to be a big issue, some sites left unchecked have come to a complete standstill because no one controlled this item.

75. Teamster drivers.

It is accepted that teamsters are truck drivers. However, on most union sites, it is taken for granted that these drivers are hauling things around the site with some order. Generally, there is no order; therefore, many more trucks and drivers than required. Since this is an indirect cost, it is generally taken for granted.

For large projects, traffic circles have to be developed to ensure the sites are serviced but with as few trucks and drivers as required. Not every truck and driver has to visit every spot on the project each day just in case there is something for him to haul.

By careful planning and monthly updates of these plans, more effective service will be provided and for less cost.

76. Non-essential material checking and receiving and paper generation.

The larger the project, the more opportunity for wasteful activities to get started and stay forever.

One of these is non-essential material checking and paper generation.

Materials are ordered by purchase orders with item numbers and quantities.

Large orders of structural steel need only have the pieces counted as they are unloaded. The count is then marked on the slip. If short, it is marked on the slip. Having checkers hanging around writing piece numbers on some lists and sending copies all over is not required, not needed and since they write the wrong numbers anyway, it causes confusion with erectors, vendors, etc.

Recommendation

A responsible staff supervisor should make the decision as to when and what will be checked. This should be evaluated against the cost if something is missing. Spending $10,000 to check something that even was missing might be worth $2,000 is not very cost effective.

We are recommending that checking materials be reviewed and if materials are checked in a marshalling facility offsite, rechecking should be spot only.

77. Labour disruptions because of no pre-job mark-up jurisdiction meetings.

121. Failure to recognize and address jurisdiction conflicts results in poor morale and is not productive, i.e.:

- Setting equipment, materials handling, small equipment operation, scaffold operation, scaffold erection, installation of supports, etc.

Generally, there are jurisdiction guidelines between the various union crafts over who does what. These follow traditional guidelines but since there are many components that can come assembled, partially assembled, mismarked, etc. and the fact that some members are not familiar with their own work, then if something new or different is

claimed by more than one union as being their work, slowdowns in the work is the result. This goes on day in and day out and is tough to manage.

Recommendation

To help manage this problem, jurisdiction mark-up meetings must be held early in the job to produce agreed upon lists of who will do what.

It is imperative that the scope is well defined and all the components are listed, including who does what if an item comes disassembled. The list agreed to is by all the union trades and the list published. Typically, the people on the owner/contractor side do not always know what the components are, what state they will be shipped in, are too lazy to list all the components or want the meeting over in one day, etc. Without a sincere commitment by the owner and contractor to establish a sound mark-up agreement, the results are continuous problems. However, if properly defined, scoped, recorded and issued, then these lists can pay great dividends. They should be updated if the scope has major deviations. This list and commitment to review in great detail the plant by plant components, execution plan for fabrication and procurement will ensure organized labour will have the total picture and with this, they will discuss deviations as they happen.

80. Accepting card members in time of shortages of skilled craftsmen.

Generally, on large projects, the planning of resources is the responsibility of the management. The skills of looking ahead to advise the union halls of the requirements, and the proper utilization of labour once received, has been poor.

Union halls have to respond within 48 hours of receiving a call for men. When they do not have the people but want to maintain control over their business, they will issue permits to people outside their union. These can be other union people of another craft that may not be as busy or they can be off the street. Since these people are less skilled they are generally less productive, but they get the same pay as if they were a skilled journeyman.

Recommendation

We must not accept permit people for the same rate of pay. We must do a realistic manpower plan. We must communicate our plans to the unions early. We must know where our alternative sources will come from. If work is subcontracted, someone has to manage the requirements of all the subcontractors and must work to superimpose their requirement on competing jobs to allow enough reaction time to ensure their needs are met.

83. Overtime beyond scheduled work week counterproductive.

143. Travel and subsistence as perks not used in place of long work weeks.

Almost every study done on the subject of overtime has concluded it is not good for cost, nor schedule, nor quality, nor safety, and yet it is used as an incentive to attract labour to remote jobsites. Since overtime, as shown in the Building Roundtable's "More Construction For The Money" actually is counter productive, then we just have to stop doing overtime and we can expect to improve productivity.

Recommendation

We can give money away in some other way to attract labour, i.e. more travel dollars or RRSP money, but stay away from overtime to attract labour. Paying costly incentives to labour, which have the effect of reducing productivity, is doubly ineffective.

84. Poor control of place of work definition (walking time).

Generally, the larger the project, the more significant this item is. If the project were small and only one plant, then the work place would be easy to define and monitor.

Recommendation

It is important that everyone understand that the work place is where the man will be working with the plant. He is supposed to be at his place of work first thing in the morning. If not defined properly and monitored by way of badge card shacks where the worker must pick up and return his badge, then he will find and define other areas as his place of work.

The location of craft badge shacks must be monitored to ensure he is not walking to work on our time. This, if monitored for start time, coffee time, etc. could result in up to 30 minutes a day per man.

85. Feather bedding built into site agreement.

For some reason, labour relations personnel think that a site agreement or any other kind of an agreement should have some give and take when it should merely be an understanding of what expectations are being agreed to.

Recommendation

If a labour agreement is contemplated, it does not have to be done behind closed doors. Owner representatives should go and monitor what is said and what is written down and agreed to. These agreements are in place for 4 years or more and must be understood by all parties, especially the impact of the so-called "give and take".

87. Too much non-essential welder upgrading.

88. Too often welders are tested, then promoted to foremen.

On most jobs, the type of materials to be welded is known but how many welders are needed and what qualifications they require is left pretty well to chance. The easy way is to test every welder for everything. Then no planning is necessary, except for turnover. If we were to stop to consider that a welder spends a couple of hours practicing for a test and that the test will take a couple of hours and that several tests are available, then we can see why it is important to do a little welder planning.

Recommendation

Once we decide the type and quantity of welds required, then we have to ensure the welders are tested for only what is needed and are available for what is needed. Too often the welder is tested for alloy pipe and then made foreman of the warehouse, etc.

Historically, we believe if we control the above, we could get by with 50% of the welders. Since welders are in short supply, we could not get fewer tests but would increase the production of each welder because as he is upgrading; he must go slower to ensure he gets the desired quantity.

89. Too much time spent on sign-up, termination, safety orientation, etc.

On a large camp job, it is almost accepted practice that 4 or 5 hours after arrival men will be given productive work.

Men normally receive a dispatch slip from the union hall and either drive or fly to the jobsite. The time it takes from the moment they come to the site to the time they actually do work could easily be reduced by 50%, moving that 50% into direct work.

Recommendation

Since we know by way of dispatch slip who is coming, we can have everything ready – room key, hard hat, employment forms, etc. From sign-up to safety orientation to camp check-in to transport to jobsite for work, much of the processing time can be streamlined by use of video equipment, etc. If 4 hours to sign-up and 4 hours to sign-out is cut to 1 to 2 hours and with the high turnover of men, several thousand hours could be eliminated here.

92. Restrictions on fabrication.

Historically, the unions prefer to do the 2" and under pipe at the job site. There is no advantage as they do not check the measurements prior to installation.

Recommendation

This work should be done off site in a shop and carefully shipped and stored in the field until installation. Many other items fall into the same category, each belonging to a different union. It is important to discuss these items early during mark-up meetings and make sure all parties have agreed to the plan of execution or these things can cost double. Any site agreements have to be carefully reviewed if they refer back to any existing agreements.

93. Deliberate work slow downs, morale.

94. Crew not part of decision making.

95. Disrespect for supervisors.

96. No recognition for good work.

Historically, senior management delegates this very important area of morale to the very people who are the cause of the problem, i.e. union stewards, craft superintendents, etc. It is therefore very important to have some forums and team building with a cross section of players from all areas.

Recommendation

A careful selection of audits by independent people with no responsibility for a given area should allow the foremen and workers to be heard on matters that will be very important to their production. All sorts of things can be done in this case, including job site newspapers, awards, etc.

97. Changes received after work is complete.

98. Changes required due to field errors.

99. Changes required due to fabrication errors.

100. Design changes, operation changes.

Historically, every site has changes for some reason or another. When changes are planned as soon as they become known, they can be completed for the optimum impact. But if, like the rest of the work changes are started by crews before everything is in place, then the same problems we have been discussing will be further impacted by the changes.

Recommendation

We are advising that changes should not be proceeded with as an extension of an existing work order, but they should be considered as new work. All the prerequisites for installing new work should be in place before changes are released for construction.

101. Quality program not understood.

102. Specifications not available.

103. Specifications not understood.

104. Specifications not interpreted properly.

On most jobs, management take for granted that the union supervisors are totally up to speed in the understanding of all the specifications and fine print. This is not the case, and even if notes on drawings refer to some document, who is to say that the worker would know who to ask or would bother to ask.

Recommendation

To ensure the specs are available and understood, it is best to assume they are not. This way, by taking the time to instruct the crew on the requirements, we have a good chance that any special items will be highlighted.

Work packages that leave nothing to the imagination will cover the normal work and will highlight the exceptional problems.

When the work planning system is in place, rework will be reduced.

107. Shutdown caused by poor safety equipment.

108. Shutdown caused by no safety equipment.

109. Shutdowns for safety violations.

When safety is not planned as part of the direct work operation and the required safety equipment is not inventoried nor inspected, both the quality and availability then become the reason for unnecessary shutdowns.

Recommendation

If the safety rules and special requirements were spelled out in the daily and weekly work plans, then the number of safety violations would certainly be reduced. Therefore, it is very important that those doing the weekly and daily work plans get instruction as to what they themselves should know in order to pass it on to the other workers.

110. Abuse of medical and/or facilities – no control.

Generally, if nothing is tracked, it does not take long for the workers to figure out that going to first aid is better than working on a cold day.

Recommendation

Since most of the men move from one foreman to another on a regular basis, simply having the foreman write a first aid slip is not the answer. Each worker should be tracked by number each time he goes to first aid. Chronic abusers should be disciplined.

111. Rental equipment not repaired, not controlled, not adequate.

Construction equipment is very costly if it is on rent and will not work. Paying for parked third party equipment has always been a problem. If it is not controlled, either too much or too little equipment is available. If no one is responsible, then you can depend that the wrong equipment will be available or if the correct number of pieces per crew were available, it would not be right for the job.

Recommendation

First, a plan of third party rentals should be made. When daily and weekly plans are made, all equipment should be accounted for. If the weekly plan and monthly plan does not require equipment, then it should be taken off rent. Each week every piece of third party and client owned equipment should be inspected to ensure it can perform.

112. Notes on drawings not clear – field to verify, field to check, field run should be eliminated whenever possible.

113. Inconsistent construction methods resulting in gold plating.

114. Incomplete information on engineering drawings.

"Field to verify", "field to check", "field to run" notes on drawings and project documents leave a great deal to the imagination. Workers love these things, especially the ones that don't say why.

Recommendation

If the drawings have notes like the above, then the reason why it must be checked, verified or field run, should be indicated. Chances are if it is to be field run, then no material has been ordered. Before the work is assigned, it must be reviewed. Better still, when doing constructability reviews in the home office, the construction manager can try to eliminate these remarks altogether.

Where incomplete or inconsistent construction methods are available, the worker will generally gold plate the installation by buffing welds, filing, etc. On a job the size of large projects, all construction methods should be reviewed with the questions:

"What would a worker do?"

or

"What could a worker do?"

115. Poor front-end or no front-end construction planning finds temporary facilities in the way of commissioning, start-up, etc.

While real estate on a construction site seems always at a premium, it takes special planning to ensure that the temporary facilities are located close to the dense work areas during construction. But it is just as important that we do not have to tear them down when they are still required because we do not have them constructed of proper materials and within the proper codes to allow them to be in the plant during start up. The locations take on some significance if all the temporary buildings are under the flare stack, etc.

Recommendation

A site facilities plan has to be reviewed by engineering, construction and owner's operation staff to ensure everything is in order. Then everything that is affected by this plan, i.e. waiting time, walking time, travelling time, access and commissioning, must be considered.

116. Temporary heating and lighting requirements not adequate, not available.

There is no question that Alberta winters are both dark and cold. This fact is very important in making sure that when work assignments are made during the winter that heat and lights are available, if not the worker will hide out until things are ready.

Recommendation

Certain heating and lighting operations can be made up in the summer time in anticipation of winter, and these lighted shelters can then be installed as the work becomes available. This item contributes not only to waiting time but also is one of the reasons that Mega construction jobs can expect about a 30% increase in winter versus summer work productivity.

117. Heating and hoarding summer vs. winter activities not controlled.

There is no question that summer productivity is better than winter and that certain activities are better done in summer than during the winter.

Recommendation

If we look at any major projects in Alberta, which will be constructed over several seasons, then there is money to be saved by doing the most costly winter work in the summer and the easier work in the winter. An example would be to do as much elevated work in the summer so that the winter would see only low level work that could be easily hoarded. Recognizing that hoarding does not solve all the winter problems, but if the work was planned to do as much outdoors during the summer, then the indoor winter work would not cost much more than summer work if hoarding is in place. Therefore, the winter 30 to 50% productivity difference could be further managed by a little planning.

118. No contingency plans in place for inclement weather.

Historically, when bad weather sets in both in summer and winter and if it is a camp job, there is a desire to get the men to work. First of all, they all go to the shacks as there is generally no rain gear. Once the rain gear is provided the only crews that generally do work are those that are unloading delivered materials. A great deal of time is wasted by supervision on running around trying to get the men out of shacks or other hiding places.

Recommendation

Since there will be bad weather on Alberta major projects, then we should ensure that during warm dry weather hoardings are built, materials are brought in under hoardings, as well as the required tools. The benefits here are just amazing. Instead of getting little or no production, we could expect excellent production if everything was in place.

119. Mobile designed welding protection not available – welding rods, rod ovens, etc.

120. No site plan for consumables, welding gases.

It is important to note that we discussed several areas where welders are non-productive or at least could be more productive. If we did not have mobile designed protection for welders, they would wait to have someone build them a proper shelter. The welder generally stands by and waits until the shelter is complete as he would not attempt to weld without the shelter and spoil the quality of the weld.

Recommendation

With mobile weld huts that fit over pipes at grade and in racks, the problem can be all but eliminated as a cherry picker can generally put a shelter in place in a matter of minutes. Here again the welder shelter should be in place before we assign the welder. Weld rod and rod ovens must also be mobile and portable or we will find we solved the shelter problem only to find the welder walking miles to find his weld rod.

122. No contingency plans for foremen or general foremen absenteeism.

Usually on a camp job, the foreman and general foreman absenteeism problem only happens at the beginning or end of the shift but when this happens, the crew of 15 or so workers will just hang around.

If no pre-planning is done, and a contingency plan in place, it will be quite a while before the men are actually on productive work.

Recommendation

Each supervisor should anticipate the absenteeism problem and be close enough to the work plan that he can make the transition to another foreman with minimum disruption.

135. The camp is located as far away from the work density (walking time).

On many large projects, there is an option as to where the camp could be located. Typically, factors such as parking, prevailing winds, interference with operations are considered, but the very important issue of how far it is from the work areas of greatest density is often overlooked. Also, since some permanent camp may be left behind to be used as a shutdown on future work, camp location has an impact beyond the construction phase. Since busing may be an option for very remote locations, the majority of men walk to and from the camp.

Recommendation

The recommendation here is to study all the options, as a 3 or 4 minute walk twice or 4 times per day, can add up to several thousand minutes extra per day and throughout the operating life of the plant construction.

136. Rework caused by insulation thickness not considered.

When engineering is sizing insulation on P&ID's, they are unable to foresee the many supports, the length of drain nipples, the number of tracers, etc. This results in many hours of rework when the plant is being considered for turnover as the experienced operators begin to

recognize the problems of freeze up at this point. Scaffolding, added insulation and lost time are then encountered.

Recommendation

Prior to the issue of insulation subcontracts, experienced operators should review the options and requirements as they are shown on the isometrics. If operations personnel could review the ISO's prior to mechanical contract, they would pick up all short nipples, drains, leads, etc. that would later impact the insulation.

Just a passing comment, maybe in remote piperacks, etc. sheet metal jacket could be eliminated and a vinyl type might be applied. A shortage of sheet metal workers could be overcome and those available could work where required.

137. Tolerances on quality control not established, more than adequate is then delivered.

Addresses Items 136 & 182

Since generic specifications are generally used on most projects, the people that understand where problems arise during commissioning and start-up are experienced operators. Historically, they do not review the tolerances for specified items and are left with the construction interpretation. For example, pumps are aligned to much greater tolerances than specified by manufacturers, and the increase in cost to get this fine tolerance is extreme. Stud bolts are specified for the installation in its final position. Hydrotesting will require studs up to three-quarters of an inch longer. These studs will be ordered extra, original studs will be removed to accommodate the longer required lengths and new, short studs will be put in place after removal of blinds.

Recommendation

As stated previously, blinds should be installed with the piping system. If a major project has 2000+ hydrotests and 2 blinds at least are required for each, then 4000 times 3 installations times 8 studs or approximately 100,000 extra studs will be installed, removed and installed again. The dollar and labour cost is certainly worth some review.

138. Poor understanding of welding requirements (rework).

139. Lack of control of weld rod material (rework).

140. Location of weld rod ovens control (rework – walking time).

The whole area of welding on most projects gets out of control very easily and if not properly understood, remains out of control. The larger the project, the worse the condition.

Starting with engineering, most drawings do not specify the welding rod or other requirements. As an experienced metallurgist is generally not resident in most shops, welding rod selection is left up to the contractor. Welding procedures are submitted, cursory review takes place but then few people know where they are or bother to follow them. Rod is poorly handled, poorly stored, stored away from the work areas, resulting in excessive walking, not heated, etc.

Recommendation

A competent person should review what is required and how it will be implemented. Savings here in rework, waste, walking, etc. will be in the thousands of dollars, not to mention the shortage of welders will be helped by doing the job once, right.

141. Radiography not up-to-date – re-scaffolding for repair.

This is another area that gets out of control very early on a project.

Generally, engineering specifies the percentage of x-rays required for a particular specification, say 10%. Each welder working off a scaffold has his first weld x-rayed then spot x-rays are selected to get the required percentage. On many occasions these are after the scaffold is taken down. It is rebuilt, reshot, repairs are required; if it is done promptly, the newly built scaffold can be utilized many times. This is not the case, and scaffolds are rebuilt much later to make the repair. If repairs are not properly identified, then the wrong place is ground out and reshot, and the whole process is repeated.

Recommendation

Recommend that the whole x-ray process be reviewed and audited. Nothing here should be taken for granted including the interpretation of x-rays. Many times unqualified personnel cut out perfectly good welds.

142. Too many / few supervisors in one area.

The whole area of craft supervision has to be constantly monitored. When crew to foreman ratios are reviewed on job sites (if ever), it is generally done from payroll records. If the ratio is 10 or 15 to 1, it is deemed in the ballpark and is accepted. But the real problem can be that if the location of these supervisors is not known, one man can be looking at 2 or 3, while others are looking at 20 or more with the resulting lack of direction. In addition, if someone is sick, late, etc. then a temporary foreman is put in position. There is no problem getting him the new rate but usually a delay in cutting the rate when he is no longer acting as foreman. Some of these individuals can keep their inflated rate for months if this is not monitored.

Recommendation

Constantly monitoring time sheets, numbers of men versus foremen and location of foremen is a must. This item not only is a waste of dollars for the foremen pay but also inefficient production can be 10 times higher.

144. Night shift not managed and controlled.

145. Hours of work not balanced to the seasons.

146. Shift work poorly planned.

147. Elevated work and height pay not controlled.

148. Layout of temporary facilities does not consider logistics, walking time, waiting time.

149. Layout of laydown areas does not consider logistics, walking time, waiting time.

150. Temporary facilities not sized for needs. Early use of permanent facilities. No control on ongoing add-ons.

155. Garbage double handled instead of bins.

156. Drinking water distributed twice daily instead of boxed water.

157. No control over broom sweeping jobsite.

158. No management of line ups at warehouse, tool shacks, toilets, etc.

159. Temporary facilities not provided in elevated structures.

All the above items have a great impact on the labour productivity on an ongoing basis.

The lack of continuous planning is the major cause of these losses.

Recommendation

To ensure we optimize the opportunities in these areas, they have to be considered up front during the plan of execution. Just as important, they must be investigated and audited on a continuous basis. An experienced construction person not tied to the day to day execution should be assigned to the project in a role similar to a methods engineer. His job would be to continuously ask the question,

"How do I know it is working?"

In order to ask and get the right answer, he must provide the standards and procedures to the rest of the team on what is expected.

161. Workers not signed up at union hall when given dispatch slip.

Historically, the union hall collects enough data on the individual to satisfy the requirements of the site payroll department. However, this information is not brought to the site by the worker.

Recommendation

It is recommended that information required by site personnel be related on the dispatch slip so workers will have the relevant data when they arrive. This item could save as much as 15 minutes per man. If 4000 men are employed at the site, it will take approximately 50,000 people to maintain this staff level.

50,000 @ ¼ hour = 12,500 manhours

(plus the staff savings to process)

162. No method provided for worker to communicate his problems to senior management on problems affecting his work.

168. Workers not motivated, no system in place that involves family, suggestion box, newspaper, rewards for cost saving methods.

On most jobs, the problem of getting feedback from worker to senior management is because there is no formal system in place.

The result is that workers think management do not care so why should they care.

We mention throughout that planning is important. Planning with involvement is more important. Planning with involvement and feedback is success.

Recommendation

When workers get their orientation for safety, quality, general job overview, etc., they must understand the method to use to give feedback. They must be asked to participate at planning reviews. They must be given an opportunity to voice their views on what is off base. We are not advocating 4,000-man quality circles, but on a similar basis, small groups can be involved representing the various types of construction operations. In this manner, we will get the feedback.

163. No contingency plans in place for staff illness or absenteeism.

164. Staff turnover not planned for.

On most jobs, it is assumed that staff will be there each and every day. The real fact is that 100% or better turnover can be expected. The result can be devastating to the workforce productivity.

Therefore, staff turnover must be anticipated and a replacement plan for promotions, turnover and sickness must be in place. Senior management should know weekly who will be in charge immediately if one member is missing. Who will stay in charge? What should be known between the parties to ensure continuity?

Recommendation

The above can be handled with good, clear job descriptions so each party knows what his replacement is doing now and expected to do in an emergency.

Establish consistent procedures for planning and controlling the work. Just imagine if a plant or area is 60% complete and the responsible manager leaves and has not been following a consistent procedure for maintaining progress, etc.

165. Qualified labourers used as janitors.

Recommendation

Tradesmen can be more productively utilized on the jobsite. Specialist contractors should be hired to perform these tasks as they are better equipped, more efficient, more cost effective and will generally work "off hours" so as to minimize disruption of daily routines.

This not only is cost effective but also will enhance local labour or native opportunities.

166. Start-up priorities not managed resulting in double scaffolding.

Historically, operations people are not on board or are too busy to plan and communicate their plan to the construction personnel. Even though the first 70% of the construction work is not dependent on how the plant will be start-up, it is very important that the requirements are understood by construction. If one system is to be turned over, then all utilities must be done. It is here that construction gets out of phase.

Recommendation

They must go through piperacks, etc. to finish one system at a time. If we had a start-up schedule, it would eliminate or indicate just what was needed. Thus, we would not have the insulation, etc. going several times through the piperacks to keep up with priorities.

169. Bad assumption that supervisors know their job, have job descriptions, are doing their job and are effective.

Recommendation

Job Descriptions should be required for all employees who are in any supervisory position. This will give the person a guideline to follow and his supervisor a yardstick by which he may measure their performance and effectiveness. Interviews should be held at the time of employment to ensure the candidate is proficient enough to carry out his duties in a safe and timely manner and to be told what is expected of him. Many balls are dropped in the field as a result of turnover of supervisors; assumptions of responsibilities are the cause of no follow-up, etc.

170. General foremen promoted without experience.

Recommendation

Prior to any employee being promoted, it must be determined if that person is capable of meeting the challenges in front of him. He must be told what is expected of him and asked if he feels he has the

experience required to fulfil these requirements. If the candidate is hesitant or unsure, he should not be promoted. Unwarranted promotion would result in increased risks in the areas of rework (non-productive time), safety, incorrect installation and incomplete work. We recommend a Questionnaire be prepared with simple "Yes", "No" answers, which would indicate what capability the supervisor has.

i.e. Did you do rigging?

Did you do civil?

Did you do steelwork?

Did you supervise before?

Did you ever build a scaffold?

The answers would allow the supervisor to be matched to the job he could do.

171. Foremen promoted without experience.

172. Assumption that construction staff knows codes of practice and regulatory requirements – If not, rework.

177. No construction methods approved for repetitive tasks such as:

- Form building
- Scaffold erection
- Steam tracing
- Conduit supports

179. Foremen and workers not given out "how to do" information for ready reference.

Foremen come from the trade and were once journeymen. There is an assumption that the next day this individual knows how to plan, manage and control. This is not the case; the foreman learns things the hard way or he never learns them at all. The results of his learning on the job is reflected in the mistakes his crew will make.

Recommendation

We must have a formal foreman training program to teach him what we want him to do. Just as we can make no assumption about the management staff, we must ensure planning, controlling, codes of practice, procedures, communications, etc. are formally given to the staff and foremen. In this training program, we must have available the construction methods on how to do the various operations. These

must be available in work packages to ensure the worker has what we intended him to have to meet our expectations.

173. No one formally checks or teaches the job requirements in all aspects to foremen and general foremen. QC, drawings, specifications.

An assumption that supervisors know all the job requirements, the specs, drawings, QC, safety, x-ray, etc., as they pertain to large projects is not a fact. Much time is wasted as they stumble to find what is required.

There is no question that the general foremen and foremen are very important to the wellbeing of the project. The problem is that management does not take care of this valuable asset. They do not get a job description and yet are expected to plan, organize, control union labour, know where everything is, how everything works, where materials, tools, equipment, etc. are stored!

The problem is management is missing the boat.

Recommendation

We need to use this key resource. We need not only job descriptions, but also we have to have courses ready to explain how we want them to interface, how all our documents and resources are planned and utilized.

We recommend a program be established that takes all the requirements and asks the question, “How do we get this across to the responsible supervisor?” The result will be several flowcharts showing him what is available, who uses it and where he gets information. Formal sessions are in order to ensure each person gets this training.

195. No formal distribution of project documentation.

Historically, out-of-date, incorrect or unapproved project documentation (drawings, specs, procedures, directives, etc.) causes much confusion, wasted time and incorrect work. Typically, with out-of-date drawings, work is installed and materials utilized, which then must be taken out and reinstalled to conform to subsequent engineering revisions. Project safety can be compromised if supervisors or workers operate under out of date directives or permits.

Recommendation

A procedure should be established before the project goes to the field identifying all project documents, their distribution, number of copies

and the individuals responsible for issuing, approving, distributing, updating and controlling the distribution of documents on one matrix.

Work orders, pre-bagged material and other work control systems should specify the appropriate drawing, spec or project document to be used for the task and be signed by the responsible field engineer.

Documents should be destroyed immediately upon receipt of the revision.

Periodic audits of document files, libraries or field offices should be made to ensure compliance.

196. Personal breaks not monitored – coffee breaks, etc.

Historically, stops, quits and breaks (S,Q,B) account for 11% of the working day. Unless monitored and rigorously enforced, breaks will "grow" to fill whatever time is allowed. Lax control of breaks also contributes to a decline in morale or commitment to the work and poor discipline on the job.

Recommendation

At sign on or site indoctrination, a set of formal procedures outlining project policy for breaks should be distributed to all project personnel, with the commitment from management that workers exceeding the break period will be docked pay or terminated. Foreman, superintendents and supervising engineers should be evaluated for their ability to manage this activity.

More rigorous enforcement of the return from breaks, including lunch, can easily result in the savings of 15 minutes (5 x 3) per day for each worker.

197. Constructability – access to steel bolted connections vs. welded connection.

Historically, during detail design welded connections are specified without due regard to alternatives. Welded connections require skilled craftsmen and more time to complete than bolted connections. Typically, the rework on unacceptable welds make the cost differential greater.

Recommendation

Input during the home office engineering phase by a construction specialist responsible for the constructability program will identify opportunities for alternatives to welded connections. Bolted connections can be specified to vendors and equipment ordered to

permit bolted connections in the field using unskilled labour. Improved productivity, lower wage ratios and less rework will result.

198. Improper crew mix.

Historically, union pressure, bias by supervisors or a "status quo" attitude, results in the excessive use of journeymen labour to execute work. Similarly, poor pre-job mark-up agreements can result in jurisdiction agreements, which require journeymen when unskilled labour will do.

Recommendation

The Building Round Table estimates that 40 to 50% of all construction work can be done by unskilled and semi-skilled labour. During the constructability planning phase of the project, the most effective crew mix should be identified and a project policy regarding labour utilization be put into place and agreed with the unions. Jurisdiction mark-ups should be agreed in the same way.

Maximizing the use of apprentices, helpers or lower cost labour categories can substantially reduce labour costs without affecting productivity. In times of a shortage of skilled labour, a properly defined crew mix strategy can increase the available labour supply by 25-50%.

Potential savings: 10% savings for each lesser skilled labour used.

Potential savings for proper usage of unskilled labour is 10% of the labour lost.

199. Constructability not done or too late, i.e. durion pipe costs 30% more labour than other acceptable alternatives.

Historically, this is one of the major causes of construction productivity problems. Typically, engineering kicks off with little or no input from construction until a construction manager is assigned to the project, just before the work moves to the field. Typically, engineering, by this time, is about 40% complete and many of the opportunities to influence design to serve an efficient construction plan are lost. Selection of materials without regard to installation cost, over design (i.e. individually designed small foundations vs. standardized foundations), excessive density of design without due regard to equipment or labour access or sequencing of design work to accommodate engineering's schedule, without proper regard for the most economic installation schedule are typical results of lack of early constructability input.

Recommendation

Early assignment of an experienced, hands-on construction expert to provide constructability input to the EPC plan is probably the most cost effective construction management decision available to and owner/contractor. A construction expert knows the problem areas in the field where 90% of the project manhours are spent. He can coordinate between E, P and C to ensure that the most efficient construction plan of execution is identified and can ensure that Engineering and Procurement schedules are consistent with the best EPC plan.

In theory, each of the 206 items identified in the study could be addressed by the construction expert during the constructability phase of the project. If the constructability plan is implemented, then some or all of the proposed savings can be achieved. If the constructability expert is not brought on to the project until later, up to half of the potential for productivity improvements will be lost.

200. Non-standardization of tubing bends for steam tracing valves and flanges, have bends made outside.

Historically, tracing is installed in the field around every valve or flange requiring tracing. This involves a pipefitter (usually 2) to bend the tubing around each valve or flange, which usually results in high levels of wasted material from unacceptable work and a substantial learning requirement as the pipefitter moves from one different size valve to another.

Recommendation

Standardize valve tracing to the maximum extent possible. Each valve and flange for each pipe diameter will have a common shape. Subcontract the fabrication/bending of tracing tubing to an offsite contractor who can build production jigs for each valve and flange size and quickly and efficiently produce the tubing bends in the thousands.

Besides the productivity savings (½ hour per bend), the project will benefit from the cheaper labour cost for offsite labour.

202. No formal control of survey crews job creation.

Historically, there always seem to be a number of survey crews active all over the site throughout the job. Typically, they are poorly managed and in a management vacuum, tend to create more work for themselves.

Recommendation

Survey work must be managed like any other activity. Survey requirements should be identified in advance and incorporated in the work packages or weekly work planning system. No survey work should proceed without authorization from a single person responsible for coordinating survey work.

203. No formal meetings for cost schedule reviews and accountability.

Historically, construction takes place in a state of "semi-organized chaos". Typically, work is not well planned at the micro level; missing equipment, materials or drawings, causing delays or changes to the original plan; reporting of installed quantities and schedule maintenance is late. It is difficult to determine the project status at any point in time and difficult to assign accountability for cost overruns or schedule slippage.

Recommendation

Once the job gets off-track, it is hard to get it back on track.

Before any work begins in the field, there should be a minimum of 3 week's work packages ready for the workers with the appropriate materials bagged, equipment available and permit requirements available. A planning team should be employed throughout the job to keep a backlog of work packages available.

This system will "feed" an effective weekly work planning and scheduling system. Work plans will not be released unless all requirements are ready. This will eliminate most delays and re-starts. Within the weekly work plan system will be an ability to "look ahead" to identify and plan for future problems. The system also incorporates a review process to assess "performance" against the schedule and budget, and to identify problem areas. Regular review can identify if problems are recurring in a particular plant, with a particular supervisor/crew or in a particular account item. This will allow management to rectify the plan and make appropriate modifications.

A regular review system is imperative for effective construction management. The review system must be based on sound, comprehensive planning and scheduling work control system.

204. No independent eyes looking at construction methods improvement.

Historically, at least on large projects, attempts are made to establish procedures and/or quality control practices to ensure that approved construction methods are utilized on the job. However, with high

turnover of both manual and non-manual staff and pressure imposed by the schedule, installation of work tends to proceed on the basis of everyone "doing the best they can" with little reference to approved construction methods. Typically, the responsibility for monitoring the compliance with approved procedures falls to the field engineer; however, on most jobs, he spends most of his time tracking down missing drawings, equipment and materials.

Recommendation

Spend the time at the beginning of the project by committing a home office construction manager to develop construction methods, procedures and a QC program, paying specific attention to the design of a Construction Audit Program. Depending on the size of the job, hire a full time construction auditor or assign a senior construction staff member with the responsibility for managing the construction audit performance and provide the construction auditor with the appropriate authority to make changes as required.

205. Manpower mobilized before plans are in place.

Historically, there is little construction input in the front-end, home office phase of projects. Usually engineering is behind schedule to achieve the schedule construction mobilization date. As a result, pressure is placed on construction to mobilize quickly and to staff up as quickly as possible to "catch up".

This means people are mobilized to the site without the requisite equipment, materials, indirect services and plans in place to allow them to work effectively. Delays, excessive rework and incomplete work characterize this phase of the job.

Not only is this costly and inefficient, it also establishes a pattern of bad management and associated poor morale, which is very difficult to overcome.

Recommendation

Involve construction early in the home office design phase of the project. Establish an overall EPC plan, which incorporates the optimum construction plan and schedule Engineering, Procurement and Construction activities to service the plan.

Well before mobilization, establish a construction planning team that will be responsible for developing a minimum of three weeks work packages. This backlog of work packages should be in place before any staff is mobilized to the site and must be maintained throughout the job. The size of the planning team must change to accommodate the level of work throughout the project cycle.

Each work package must be planned and scheduled and must identify and have confirmed, before release for construction, all materials, equipment, permits and any prerequisite work required.

This is a fundamental principle upon which our proposed productivity improvement program is based.

206. Breaks to do accounting/pick-up drawings, specifications.

Historically, foremen are responsible for completing timesheets and picking up drawings and specs, as well as for the supervision of manual labour. Typically, the foreman spends a great deal of his time tracking down manual staff to complete or correct timesheets, to deliver timesheets to accounting or review timesheets or to track down drawings and/or specs that either have not been delivered or to replace out of date documents. While doing these logistical activities, the foreman is not supervising or advising his crew. In his absence, the crew stop working or at best slow down. Breaks are excessive and not controlled. Morale breaks down and productivity suffers.

Recommendation

Do whatever is required to keep the foreman on the job in direct contact and control of his crew.

Hire clerks to look after accounting and timesheet requirements. As recommended elsewhere, staff a planning group to develop work packages and ensure that all drawings, specs, etc. are included in the work package.

A small planning staff and a few payroll clerks can have a huge impact on productivity and costs. One clerk supporting 10 foremen (who supervise 8 to 10 men) could have significant direct impact on the improved productivity of up to 100 men.

207. Due to lack of work packages, foremen spend time on equipment – searching – trying to do re-engineering, figuring what is required (i.e. engineering).

Due to lack of work packages, foremen spend too much time searching for equipment and documentation or re-engineering work to sort out what is required.

Historically, work is poorly planned at the level of individual work packages. Equipment is not available; material supplies are incomplete; drawings are missing or out of date.

As a result, the foreman spends too much time finding missing materials or documents or trying to re-engineer the work to “fit” what he has.

While the foreman is doing this, his work crew stands around waiting for direction and/or work to do.

Every hour wasted by the foreman, in non-productive work planning, is multiplied by 8 to 10 times due to his counterproductive crew.

Recommendation

No work should be released for construction without all requisite documentation, materials, equipment, permits, etc. in place to allow the work to proceed.

A work planning and scheduling system, based on a backlog of 3 weeks of “ready-to-go” work packages, at all times is a prerequisite.

A small investment in a work planning team can pay off a hundred-fold in terms of reduced field planning requirements for foremen and associated non-productive waiting time for the craftsmen.

### 3.4.8 Assumptions and Authority

Items addressed from Section 3.3, Construction Productivity Problems:

- (182 – 190)

182. Assumption that subcontractors are capable.

183. Assumption that all modularization is effective.

184. Assumption that schedule must be achieved.

185. Assumption that vendors are qualified.

186. Assumption that Boilers Branch inspectors are qualified.

187. Assumption that Electrical Branch inspectors are qualified.

188. Assumption that vendor representatives are knowledgeable.

189. Assumption that OH&S inspectors are qualified, for all unique situations.

190. Assumption that Owner representatives are qualified.

On most jobs, these people speak with authority. Even though this is not directly related to actual productivity in this study, it is a known fact that these people can influence the costs on an ongoing basis. Their unquestioned authority is generally just implemented.

Recommendation

The recommendation here is that an atmosphere of total questioning be in order, to take nothing as gospel but to allow questions.

"Where does it say that?"

or

"Why does it have to be like that?"

# 4.0 MONITORING / AUDITING PROJECT PERFORMANCE

The purpose of this section is to develop a tool that will enable project managers to audit/evaluate project performance during execution and to determine where improvements can be made. When used in the planning phase, it might serve as a checklist to ensure successful completion of a project. The checklist is by no means a complete cookbook recipe for success but can serve as a guideline so the right questions are asked and certain minimum criteria are considered. Mega projects in the oil and gas industry served as the basis for the design of the monitoring tool but with modification, the tool could be applied to most construction projects.

In order to evaluate or plan a project, 14 key components are identified and given a weight by the authors (out of 100). These key components and their associated weight are:

| Key Components: | | Weight (%) |
|---|---|---|
| 1) | Cost Management | 6% |
| 2) | Schedule Management | 10% |
| 3) | Work Planning | 12% |
| 4) | Progress and Productivity | 10% |
| 5) | Quality Management | 8% |
| 6) | Safety Management | 8% |
| 7) | Organization | 7% |
| 8) | Labour Relations | 7% |
| 9) | Materials Management | 12% |
| 10) | Subcontract Administration | 6% |
| 11) | Managing Construction Equipment | 4% |
| 12) | Management of Construction Tools | 4% |
| 13) | Management of Temporary Facilities | 3% |
| 14) | Scaffolding Management | 3% |
| | Overall | 100% |

Each key component is further divided into its basic elements. Each element is assigned a weight. Each key component contributes to the overall project score.

It is to be noted that the tool and the weighting is “subjective” and is based on the authors’ industry experience in construction and project management. With this understanding, a manager can then apply the tool as is, or modify it to suit specific project requirements.

The auditor (the user of the tool) should have some experience with construction projects as the scoring is left to the auditor and will also be subjective. The scores awarded are then entered and processed with their corresponding weights. A

summary sheet with a detailed breakdown then can be prepared by the auditor so that problem areas can be pinpointed and remedied.

For each criterion, an assessment of each activity is required to perform this assessment; it was necessary to define our expectation for each activity. The expectation was broken down into the elements critical to its achievement.

A brief description for each activity under each criteria was developed. The description is designed to help the auditor ask relevant questions and gather responses, which identify how a construction manager addresses the critical elements. This formed the basis of the grade for the construction manager.

The grade times the activity weight yields the activity score. The activity weight was determined by the authors.

The criteria grades can then be totaled, and the overall grade of the construction project or manager can be calculated.

While subjective, we believe that a minimum grade of 75% is required for an acceptable construction manager.

The following subsections describe the evaluation criteria and activities with our suggested weight.

## 4.1 Cost Management — Weighted Value 6%

Cost Management, through the use of a cost monitoring system, is an important tool in project control. Three basic concepts should be covered. The first function that should be provided is a continuous monitoring of project expenditures against a control budget. Secondly, accurate forecasting of final project costs should be possible. Lastly, the identification of problem areas should be carried out so that overruns can be avoided. A cost control system should include some or all of the following elements.

1. Establish Control Budget Based on a Code of Accounts (WBS) 40%

   In order to manage and control the costs on a project a control budget must be established as a cost baseline by which all costs are recorded against. The control budget must be in sufficient detail to allow control of expenditures and accurate forecasting of costs. Forecast and expenditures can easily be compared to the control budget and variances clearly identified.

2. Continuous Monitoring of Project Expenditures Against a Control Budget 20%

   The costs incurred during the execution of a project must be continually recorded and compared to the control budget. Project expenditures include actual costs and committed costs to date. When forecast cost overruns or actual overruns become apparent action can then be taken to avoid them.

3. Detailed Cost Code of Accounts 5%

   In order to exercise control over cost incurred during the execution of a project the project costs must be broken down to a sufficient level of detail. Project costs are normally broken down on a Work Breakdown Structure (WBS). This allows the construction team to easily identify where problem areas exist. The WBS or cost code of accounts is the basis by which the control budget is broken down and incurred costs recorded.

4. Forecast of Final Cost in Each Detailed Account Code 10%

   It is necessary that forecasting be done throughout the life of the project for the final projected costs for each detailed account. It is only when variances between the control budget and the forecast final cost exist can action be taken to remedy the situation. Many problems can be eliminated on a project by having early detection systems and taking corrective action.

5. Trend and Change Order Procedure 10%

   Trends and change orders are a mechanism for identifying items, which may affect project costs or schedule, and to provide a means for adjusting the project budget (or contract value on a lump sum project), project forecast final cost, and project schedule. A trend and change order system also provide a means by which changes in cost schedule and scope are clearly documented for future reference. If cost or schedule overruns do occur they provide the necessary documentation as to the reason why.

6. Updates to Budgets and Forecast Based on Approved Trends and Change Orders 10%

   Very often during the execution of a project the control budget or cost baseline will need to be adjusted to reflect the current state of conditions. A "trend" is defined as any occurrence, which could lead to a change in the forecast of project cost or a change in the project schedule. A "change order" is defined as an authorization by the Client to change the scope of the project and hence change the project budget and/or schedule.

7. Detailed Cost Report 5%

   The project cost report is the principal document for the recording and analyzing of costs incurred during the execution of a project. It provides a mechanism for comparing actual against budgeted costs and requires that a forecast be made during each reporting period of the final projected job costs for each detailed account.

Sub-Total 100%

## 4.2 Schedule Management — Weighted Value 10%

Another project control tool is the effective use of schedule management techniques. Project schedules and the execution plan should establish guidelines as to how and when the project is to be executed. Schedule requirements need to be communicated to the task force involved and inter-disciplinary co-ordination is effected using proper schedule management. As well as these factors, schedule management provides a basis for monitoring the work. The elements listed below should be contained in an effective schedule management program.

1. Integrated Engineering, Procurement and Construction Schedule Based on CPM Network Theory 30%

   Construction is dependent on both engineering and procurement. It is therefore necessary to have a construction schedule, which is integrated with the engineering and procurement schedule. Schedules always change with certain activities being accelerated while others are delayed. It is imperative that construction quickly adapt to any changes in engineering and procurement.

2. Successive Levels of Construction Schedules Consistent with the Project Master Schedules — 10%

   The level of detail required on a project schedule varies according to the "end use" of the schedule. It is common on a project for there to be 3 or 4 levels of a schedule, with one being more detailed than its predecessor. It is important for the daily work plan to be consistent with the weekly work plan which is consistent with the project schedule which is also consistent with the project master schedule.

3. Construction Weekly Work Plan — 10%

   This schedule covers the day to day planning of specific tasks and is intended for the supervisory staff on a construction project. The weekly work plan is the main tool used by construction personnel to execute the project. The weekly work plan is based on summary level schedules, which is consistent with the project master schedule. It is the front line schedule, which attempts to keep the project on course.

4. Construction Progress Curve — 15%

   The Construction Progress Curve is simply a graphical depiction of the progress that is planned over the course of the project based on the schedule. It is important for the construction group to see that the schedule is attainable and to monitor its progress against a plan. As the scheduled activities are completed, actual progress can be compared to the planned progress. It is only when deviations are highlighted that corrective action can be taken.

5. Construction Manpower Histogram — 15%

   Each activity on a project schedule can be manpower loaded. The manpower load on each activity can then be added together to produce a manpower histogram for the project. The manpower histogram is useful in illustrating the manpower requirements for the project. The manpower histogram helps the construction management know how many men they will require to execute the project on schedule.

6. Project Key Dates and Milestone Schedule 5%

   Establishing intermediate milestones throughout the course of the project is a useful management tool in an attempt to keep the project on schedule. Everyone is well aware of the project end date, however milestones established throughout the project assist management in achieving the project end date.

7. Schedule Updated and Progressed at Regular Intervals 10%

   In order to have an up-to-date schedule, which reflects the current situation of the project, the schedule must be updated and current status recorded at regular intervals. Project schedules may change throughout the course of the project as new and better information becomes available. It is important to incorporate these changes into the schedule to better manage the project. A project schedule can soon become outdated if not updated regularly.

8. Schedule Weekly and Monthly Reports 5%

   Key personnel must be made aware of schedule requirements prior to and during the course of the project. In order for people to follow the schedule they must be made aware of it, and the impact of their schedule responsibilities on the project.

   Schedules must be updated on a regular basis and exceptions to the schedule must be brought to management's attention so that corrective action can be taken.

Sub-Total 100%

## 4.3 Work Planning — Weighted Value 12%

When the project enters into the construction phase short-range detailed planning commences. Planning is at the crew level and involves the identification of complete resource requirements for each task, the verification of the availability of those resources, and the provision of those resources when needed.

The following is a list of criteria that should be incorporated in the detailed construction planning if the project is to be executed successfully.

1. Definition of the Scope of the Work Package to be Executed 25%

   For the purpose of this discussion we shall refer to tasks and activities to be completed on a construction project as work packages. A work package must be a well-defined scope of work that terminates in a deliverable product(s). Each package may vary in size but it must be a measurable and controllable unit of work to be performed. Construction personnel must have a clear understanding of the work to be performed.

2. Work Package Prerequisites Identified and Completed 25%

   Before commencing a work package in a certain area all prerequisites must be identified and completed. These may include scaffolding, hand and power tools, craneage and rigging, special work permits, appropriate jurisdictional identification, personal protective equipment, construction equipment, bulk and pre-fabricated materials nearby and engineered drawings, specifications and procedures.

3. Planning Work Packages with Safety Considerations 10%

   If safety considerations are made while planning the work package the chance of an accident occurring is substantially reduced. Safety procedures must be incorporated in the execution plan in order to be effective. Such things as obtaining permits, signing off scaffolding, personnel protective equipment, etc. are important when executing the work package.

4. Work Plans Consistent with the Project Construction Schedule 10%

   The time frame in which individual work packages are scheduled must be in line with the project construction schedule to ensure the objectives of the project are met. For example, the project schedule will indicate the time frame in which foundations are to be constructed. The scheduling of individual work packages must coincide with this time frame to ensure the successful completion of the project.

5. Use of Effective and Efficient Construction Methods 5%

   When planning the step-by-step execution of the work package, construction supervision should ensure that standard construction techniques are utilized and the quality of work will meet or exceed project requirements.

6. Defined Resource Requirements (Manpower) for the Work Package 5%

   Care must be taken in assigning the correct trade to execute the work. The number of men and types of tradesmen involved should be clearly defined to avoid any possible conflict and to ensure the availability of manpower.

7. Identified Cost Codes to be Charged Against When Coding Time Cards 2%

   In order to be able to track manhours expended against a specific work package and hence calculate productivity care must be taken to check time cards. Emphasis on correctly coding time cards will help control hours spent on a given work package.

8. Identification of Who is Responsible for a Work Package 8%

   It is important to assign supervisory responsibility for the execution of a work package. People need to be held accountable for their work.

9. Checking Work Progress While Identifying and Solving Unforeseen Problems 10%

   Once a work package has started, it is important for the Supervisor to periodically check the work progress and ensure nothing inhibits that progress. After the work package is completed it is also important for the Supervisor to inspect the work package to validate its completion.

   Even though sufficient planning may take place prior to starting a work package, it is inevitable that unforeseen problems may arise. A quick solution to unforeseen problems is required for the efficient execution of the work package.

Sub-Total 100%

## 4.4 Progress and Productivity — Weighted Value 10%

The purpose of a construction progress monitoring system is to provide a consistent method of measuring the physical percent complete of construction activities and to identify adverse trends in progress and productivity. This identification will allow corrective actions to be taken to mitigate the consequences. Management of a progress and productivity program should include the following elements.

1. Accurate Measurement of Physical Percent Complete of Construction Activities — 30%

   In order to determine whether the construction progress is on schedule or not, the actual progress must be measured and compared to the planned progress. Actual progress is measured by measuring the physical quantities installed to date and comparing it to the total quantities to arrive at a percent complete.

2. Regular Progress and Productivity Measurement Intervals — 10%

   In order to chart the progress of the project and attempt to maintain the project on course at all times it is important to measure progress and productivity at all times. Thus at any given time deviations can be identified and corrective action taken.

3. Forecast Final Construction Manhours — 10%

   If progress and productivity are constantly measured, project controls personnel will be able to continually forecast the total manhours and the manhours required to complete the project. A forecast to completion enables management to realistically re-plan and re-schedule the project if the need arises.

4. Calculate Productivity Factors by Comparing the Earned Manhours (Progress) versus Actual Expended Manhours — 20%

   Productivity factors are an indicator used by management to determine whether the project is being executed efficiently or not. If poor productivity is reported it is an indicator that work is proceeding in an inefficient manner and corrective action must be taken.

5. Regular Progress and Productivity Reviews and Reports to Construction Management — 20%

   The communication of project controls information to construction management in an efficient and effective manner is of paramount importance to the construction team. Deviation in the schedule, progress and productivity (which are one in the same) must be identified early to allow management to take action to bring the project in on time.

6. Accurate Measurement of Expended Manhours per Construction Activity — 10%

   In order to accurately calculate the productivity of construction activities one must be able to accurately determine earned and expended manhours. Foreman and general foremen must ensure proper coding of time sheets so that expended manhours can be determined. Miscoded time sheets lead to inaccurate productivity

factors.

Sub-Total 100%

4.5 Quality Management Weighted Value 8%

Project quality will influence the success of the project at hand as well as the long term success of the contractor. Quality involves completing the task correctly to meet the governing specifications. If a quality product is to be the end result then in order to achieve it efficiently the task must be performed correctly the first time. Pride of workmanship in producing a quality product can contribute positively to project success. A quality project reflects favourably on those involved so that subsequent endeavours are possible. From a contractor's point of view this would mean bidding on larger and more complicated projects as successful completions are attained. The following points are indicators of how an organization is performing in the management of quality.

1. Level of Quality Included in Design or Plan 30%

   The designers, planners and management of a project must be cognoscente of the fact that this function alone can determine more than any other the eventual quality of the product. The planners must have enough experience, information and resources to allow for enough competent tradespeople to be on the site at the required time with the correct tools and adequate material to produce a quality product.

2. Material Control System 15%

   This system must track the material through ordering, identification, receiving, storing, and eventual use. Material must meet specifications and the correct material must be used in the appropriate application. This involves specialized purchasing in some areas and a tracing system with tagging in most.

3. Competence of Workers and Supervisors 15%

   Workers must be qualified to do the work and supervisors must be experienced enough to still produce a quality product under slightly adverse conditions. Ticketed tradespeople exhibit a certain base skill level and should be employed appropriately. Extra training for new procedures should be available if no experience can be hired.

4. Management Support 10%

A Quality Control Manual is an indication of management's commitment to quality in an organization. Management's roles and responsibilities should be laid out in the manual. A QC Manager should have enough authority t6 effect change where required to assure quality. The responsibility for quality should be spread throughout all functional areas of the organization.

5. Pride of Workmanship 10%

Quality work should be recognized and commended by supervisors and a reward system is not out of the question. The "quality attitude" should be promoted and workers empowered to produce a quality job.

6. Timing of Quality in Project Life Cycle 5%

The QC Manager should ideally have input to a project very early in a project life cycle in order to identify areas where quality might be compromised. Once again the QC Manager must have the authority to act.

7. Non-conformance Reporting and Inspection 5%

Non-conformances should be documented and acted upon by the QC Manager. Procedures must be flexible enough to allow change where quality is being adversely affected. Statistics should not be kept for their own sake rather to highlight problems and instigate corrective action.

8. Role of QC Inspector 5%

Workers and supervisors should be able to determine what is expected from a quality standpoint. Written policies and specifications should be available for reference when employees are wondering about quality.

9. Subcontractor Monitoring 5%

Since much of a project is often subcontracted, responsibility for subcontractor quality monitoring should be assigned. This can be the QC Manager who must be competent to judge the work involved. A mechanical contractor who subcontracts the electrical portion of a project must have adequate inspection experience in electrical to effectively monitor quality performance.

Sub-Total 100%

## 4.6 Safety Management — Weighted Value 8%

Everyone connected with a construction project should be concerned with the level of safety that is maintained on it. Job site safety influences productivity and morale which in turn can determine whether the project will be completed successfully or not. As a minimum, the level of safety on a project must comply with certain legislated criteria. Beyond these minimum requirements many real and often monetary benefits can be realized by promoting a safe work environment. There are many factors that contribute to a safe project. The following points are indicators of the level of safety that a project might experience.

1. Safety in Design — 20%

   Not only must the end product under construction be safe but the actual construction methods must be safe as well. If a structure is to be erected that poses some risk then the level of risk must be assessed and addressed in the design stage. Alternate safer designs should be considered. Methods that will attain the same end result but take a different route to completion should be examined. Corporate policies, procedures, and practices should be spelled out to define safe construction methods. Individuals should not have to redefine and experiment with different methods for every task. Engineering controls should be in place to mitigate the risks inherent in some construction methods.

2. Training of Workers and Supervisors — 20%

   A certain level of experience must be demanded of supervisory personnel so that tasks do not become examples of the blind leading the blind. The supervisors must in turn be provided with workers that also possess skills that are appropriate for the work at hand. There should be opportunity for both workers and supervisors to obtain safety training on an ongoing basis as well as have access to proper safety equipment.

3. Planning for Methodology and Hazards — 20%

   For each new task, there must be adequate procedures in place as well as personal protective equipment. Project wide hazard assessment is required as well as a task specific inspection. Supervisors must have adequate resources to plan out effectively the safe performance of the task and then to communicate this information to the workers.

4. Safety Program 10%

   The safety program must comply with legislation as well as Client requirements. Approval from some sanctioning safety organization is desirable. Responsibility should be laid out from top management down to project worker as to how the program is to be implemented effectively. The program should contain clear simple rules and regulations.

5. Management Support 10%

   Senior management should take an active participatory role in the safety of company projects. Participation in safety committees, training and meetings should occur. It is management's job to assign responsibilities for safety, and this should be clear.

6. Safety Training 5%

   New hire orientation, weekly or monthly safety meetings, toolbox meetings, safety committees and safety courses are all indicators of an organization's commitment to safety training.

7. Maintenance Program 5%

   Preventative maintenance on tools and equipment involving records and logs should occur. Workers should be made aware of the dangers of working with defective tools and encouraged to report and flag these problems.

8. Emergency Preparedness 5%

   All project personnel must be able to contact emergency aid and find emergency equipment. An adequate number of first aid trained employees must be on the job site and drills or simulations conducted to ensure preparedness.

9. Records and Statistics 5%

   The effort expended in keeping records should not be to accumulate historical data but to learn from past mistakes and take corrective actions. Near misses should also be included and the information that these statistics generate should be used to educate the workers in safe work practices.

Sub-Total 100%

## 4.7 Organization — Weighted Value 7%

The success of any construction project is highly dependent on the quality of the people who are managing the job. Ensuring that the right people are in place at the right time is important. To best assess and manage the construction organization, the following elements should be established on the project.

1. Personnel Selection Methods — 30%

   Personnel selection methods must be based on the needs of the job. The contractor must have a method for objectively evaluating his personnel against the requirements of the job at the outset of the project. The selection methods will be based on the individual's skills and experience. A means for getting client input and acceptance on the selection of key project personnel is required. The method should also contain provisions for ongoing review and upgrading of personnel requirements and qualifications throughout the project.

2. Organization and Reporting Structure — 25%

   Effectiveness of the overall construction management effort is dependent upon the structure and reporting features of the organization. In order for the project to be successful, a construction manager with full responsibility and authority for all decision making must be on site 100% of the time. The major key result areas for the construction project of safety, quality, cost/schedule and technical must all report independently to the Construction Manager. The Construction Manager will have single point responsibility to the Client Construction Manager on all contractual requirements.

3. Home Office Construction and Engineering Liaison — 15%

   Success of the construction project will depend upon the effectiveness of liaison between the contractor's field construction staff and his home office engineering staff. Since most projects start the construction phase before engineering is complete, smooth orderly flow of drawings, specifications and change documents between the home office and field is essential. The contractor must have an observable good working relationship among staff members, and good procedures for coordination and managing work. Good procedures would be characterized by features such as regular coordination meetings, the presence of a Home Office Construction Manager and well-coordinated engineering and construction schedules.

4. Staffing and De-staffing Plans and Procedures 15%

In order to ensure that the right people are in place on the construction staff at the right time, and that construction staff costs are being controlled, the contractor must have a staffing and de-staffing plan for the project. The plan will document when each staff position will start and finish on the job, preferably in the form of histograms. The staffing plan will also include policies and procedures governing relocations, working days, overtime and vacation policies, etc.

5. Training Programs for First Line Supervisors 15%

The success of the project in terms of construction labour productivit in managing safety, quality, cost, and schedule, not just production. Relevant training programs would help to improve supervisor's skills and abilities, to instill the values of good construction management and help to retain qualified people in the industry for the long term.

Sub-Total 100%

## 4.8 Labour Relations — Weighted Value 7%

On all construction projects, both union and non-union, construction labour relations is an important aspect of the job. In order to maximize the owner's value for his money, it is important that everyone connected with the project be working to the same set of objectives. Developing good working relationships with the tradespeople who are working on the job can best assure that everyone's objectives are being met. To best assess and manage the labour relations program of a project, the following elements should be considered.

1. Workforce Planning 35%

Proper work force planning will ensure that the right numbers of qualified tradespeople will be available on the site to perform the work each day. This implies that the schedule will be optimized by having enough trades people and that costs will be minimized by not having too many. As a planning tool, histograms by trade, built from the direct labour man-hour estimate, should be used and kept up to date as the project progresses. In the case of unionized construction, trades person level requirements and specifications should be reviewed at the start of the job with the unions involved at an equipment mark-up meeting. This will identify craft level requirements in each area and any potential jurisdictional disputes that could occur later. Contingency plans should be made by the construction planning staff for any major work disruptions, such as strikes.

2. Apprenticeship and Training Programs for Craft Labour 25%

As a means of attracting and retaining good qualified tradespeople, the contractor should be offering a training and apprenticeship program on the project. The programs should be offered to all trades as an incentive to stay on the project long term, and to excel at their trade. Training programs will also increase the levels of safety and quality on the project. The training program should result in some tangible rewards and recognition, such as trade certification where possible, promotions or bonuses. Owner participation in these types of programs is essential, since there is usually a cost involved, and also because the owner directly benefits by having a better project.

3. Grievance Handling 20%

Avoidance or proper handling of labour force grievances on the project can minimize the cost and schedule duration of a project. The key to effectively handling grievances by the contractor is good planning. The contractor should have well documented site policies and practices in place, which have been reviewed and are understood by the labour force. The policies should include the handling of specific grievances, rules for handling work assignments to the various unions where needed, composite crews, etc. Where applicable, a camp committee with access to the Construction Manager should be in place.

4. Workforce Recruitment 10%

An effective work force recruitment program will ensure that the project hires the best available tradespeople for the job. Work force recruitment will be the responsibility of the trade foreman with input from the Labour Relations Coordinator and where applicable the Construction Manager. The contractor will base recruitment on personal experience with the particular individual through job-to-job records of good and poor performers. Selection criteria will include safety and quality records.

5. Labour Relations Coordinator 10%

The project should have a qualified Labour Relations Coordinator on the construction staff for the majority of the project. The Labour Relations Coordinator will be assigned to the project before field work begins, so that the work force planning and recruiting activities will be well managed, and will remain in the field office until the majority of the trades people are off the job to manage work force de-staffing. The key responsibility of the Labour Relations Coordinator will be to pro-actively manage site labour relations by anticipating and avoiding labour problems.

Sub-Total 100%

## 4.9 Materials Management — Weighted Value 12%

The total cost of materials on a typical process plant project is about 35% of the total project cost. At the construction site, the biggest challenge facing the construction staff is the timely and efficient receiving, storage and issuing of materials to the work force, and providing accurate information about the status of the materials under their control. To assess the effectiveness of the materials management capabilities of a project, the following elements should be considered.

1. Materials Planning — 30%

   Materials planning involves the preparation of a comprehensive set of procedures for how materials will be handled on the project site. The procedures will address the needs of the project from the initial identification of materials on quantity take-offs, through purchasing, inspection, expediting, transportation, receiving, storage, issuing and returning of surplus. The procedures will identify who has responsibility for each aspect of materials management, and be well understood by the materials management staff.

2. Purchasing — 15%

   The majority of the materials purchased on a project will be purchased from the contractors home office. However, the way in which the materials are purchased can have a large effect on the success of the construction phase of the project. The largest effect will be from the delivery of materials. Therefore, it is important that purchase orders be issued in a timely manner. Bidding should be done to reputable suppliers who have a history of being able to meet promised delivery deadlines. The use of contracting incentives to ensure timely delivery should be considered to enhance the success of the project. In the case of field purchasing of materials, a good coordination procedure between the contractors home office and field based staff is essential to ensuring that no over- or under-lapping of purchases takes place.

3. Receiving and Issuing — 15%

   The receiving and issuing of materials is important to the level of accuracy and confidence in the materials management procedures being used by the contractor. The materials management staff will know from purchasing and expediting reports when all materials can be expected to arrive at the site, so that receiving can be done effectively. Acceptance inspection for compliance with purchase requirements and quantities will be carried out as materials are received, and any shortages, surpluses or deviations from specifications will be dealt with immediately. When materials are requisitioned by construction forces and issued, the quantities and locations are noted and recorded immediately, meaning that

materials status and inventory levels are always up to date.

4. Inventory Management 25%

The management of inventory levels of various materials that are used on site is extremely important to ensure the smooth flow of work on the site. Project costs and schedules can be adversely affected by a lack of materials at the site to perform the necessary work. The keys to a good materials inventory procedure is to know at all times what materials are on the site and where they are. This can be done by gridding the site and noting the location of all bulk materials and equipment pieces within that grid when they are received. This will prevent the loss or misplacement of any materials. Similarly, the tagging of warehouse bins and recording of parts into specific bins as it is received will ensure that the right parts can always be found.

Methods of accurately establishing inventory levels are very important to ensuring that sufficient amount of materials are on hand to allow work to proceed. Inventory management must ensure that procedures are in place to re-order materials in short supply, to expedite those that are overdue, and to identify any that are forecast to be surplus.

5. Materials Management Systems 15%

Materials management is largely an exercise in managing information about purchase orders, receipts, issuing, inventory levels, shortages and surpluses. The earlier that the project staff can get accurate information about their materials levels, the better equipped they will be to pro-actively manage their part of the project. On large projects, computer based materials management systems will be in the best position to provide and manage the information on materials.

The best materials management systems are those that are capable of being easily understood and updated in a timely manner. The materials receivers and warehouse personnel will be capable of entering information about receipts and issues directly in to the system themselves without specialist or clerical help. The information in the system will be equally accessible and completely reliable, so that decisions on inventory levels can be made with confidence. The materials management systems will be capable of reporting on purchase order status, quantities of materials required, ordered and issued, inventory levels, locations of all major equipment pieces and bulk materials based on the site grid or warehouse bin number, and forecasts of materials surpluses and shortages.

Sub-Total 100%

## 4.10 Subcontract Administration — Weighted Value 6%

On most major construction projects, subcontracted work makes up a significant amount of the total project expenditure. Subcontracting is usually done to utilize specialty contractors and optimize cost and schedule performance, or to meet other project objectives such as local participation. To assess the effectiveness of a project's subcontract administration program, the following elements should be considered.

1. Subcontract Planning 40%

   Like all other aspects of a project, subcontract administration will be most successful if it is well planned before the start of the project. Planning for the management of subcontracts should involve determining and documenting the subcontracting objectives, such as maximizing local content or minimizing the special equipment to be bought or leased for the project. Subcontracting plans must be identified early and be consistent with the overall project objectives.

   The major subcontracts should be clearly and distinctly identified in the project work breakdown structure. By doing so, they can be managed under their own budget and schedule. Subcontractor requirements must be incorporated into temporary facility and equipment requirements for the entire project.

2. Bidding and Awarding 10%

   To ensure project success, only fully qualified and capable subcontractors should be allowed to bid on the project. Pre-qualification of bidders using criteria such as quality, reliability and safety performance will ensure that a competent bid slate is developed. Standardization of bid documents will make the contractors administration and leveling of the bids an easier task. Single point responsibility for subcontract bidding and awarding within the contractor's organization will keep communications clear.

3. Subcontractor Coordination 40%

The day-to-day management of the subcontractor's work and its coordination with the rest of the project activities is a very important aspect of the project. Subcontractors must be treated the same as any other of the contractors crews and must be included in all site management and coordination activities. It is important that each subcontractor work through a single point contact within the contractor's organization for simplicity and clarity of directions. All subcontractors who are on site at the time must be represented at project coordination meetings. Tracking and progress measurement standards and procedures must be in place and well understood.

Subcontractor safety performance is still the ultimate responsibility of the contractor's Construction Manager. Subcontractor safety must be managed the same as the safety performance of the contractor's direct hire forces. All subcontractor personnel must be given site safety orientations by the contractor before they can begin their work. Subcontractors must be made to feel the same level of ownership in the projects safety program.

4. Acceptance 10%

Final acceptance of the subcontractor’s work is important for cost, schedule and quality considerations. To facilitate final acceptance, standards must be developed at the bid and award stage defining what the scope and expected level of quality for the subcontract are. The contractors quality assurance staff should take equal responsibility for subcontract work as for direct hire. Acceptance and turnover procedures must be developed and documented, and final inspections carried out and documented.

Sub-Total 100%

## 4.11 Managing Construction Equipment Weighted Value 4%

The productivity and efficiency of the construction equipment on a project is directly linked to how the equipment is utilized and how the operator and crew are assigned.

To ensure productivity improvement the following elements should be established and implemented as an equipment managing strategy.

1. Equipment Supply and Work Schedule 15%

   Restricted availability and long time delivery of some kinds of heavy equipment requires advanced planning for having the equipment on the construction site at the right time. An equipment work schedule is necessary to establish the length of time which the equipment will be employed.

2. Right Person-Right Machine-Right Job Concept 20%

   With increasing equipment costs it is very important to keep the same skilled operator on one piece of equipment whenever possible. He gets to know it and learns what it can and can't do. This knowledge leads to the next facet of the concept, putting the right piece of equipment on the right job. One idea might be to apply a small sticker that reminds the operator to check oil, water and tires daily and follow it with a statement, "You work when this machine works." This may seem a bit harsh, but the reality is that when machines are idle for any reason time and money are quickly wasted.

3. Crew Continuity and Motivation 20%

   Crew continuity is simply a matter of keeping skilled people working together. They soon learn what each other does best and know what the equipment can do, and from there on, the learning curve takes over. If you can keep the same group of people with the same equipment doing the same kind of work, even when they are moved from one location to another, you are able to utilize your human resources and your equipment more effectively and productively.

   There are many motivation techniques that can be used to increase individual and group productivity. One of them may be goal setting for each person or crew for the day. Employee feedback and ideas that are acted upon also increases morale.

4. Development of Equipment Availability and Utilization Data 10%

   An equipment utilization reporting system or equipment usage report is a formal effort to track how much time the equipment is available to be used and how much time it is actually used. These availability and utilization figures may be used to evaluate equipment and manager/supervisor performance and accumulate a long-term history of equipment performance. To develop these figures, the system should gather the hours of downtime and idle time for a machine, as well as the hours of usage for it.

5. Equipment Safety Checklists 15%

Equipment safety checklists are designed to ensure maintenance of equipment in good operating and safety conditions. Depending upon the kind of equipment, safety checklists should be filled out periodically by the operator, a safety inspector or a professional engineer.

6. Equipment Maintenance Program and Facilities 20%

The equipment maintenance program and facilities should provide maintenance of the equipment in good working order and high level of reliability.

Proper equipment maintenance is a key to profitability. Without a system for maintenance a contractor is asking for trouble. An equipment breakdown results in costly waiting time.

For all smaller equipment which may cause a time loss, standbys or spares are needed at the job site.

Costs of maintenance can get out of hand if it is not watched. When the costs of repairs done by outside shops approaches the cost of having a qualified mechanic on site, then it is time to hire one.

Having a mechanic on site gives the advantage of quicker service and closer attention to the equipment. Minor repairs at an early time and preventive maintenance will prevent major repairs later on.

Sub-Total 100%

## 4.12 Management of Construction Tools — Weighted Value 4%

Procedures for the management of tools on the construction site need to cover the following points.

1. Location of Tool Rooms 20%

Because of the large variety of tools needed to perform construction work, some of them, especially expensive, universal tools and tools which are not in permanent use, should be located in the tool rooms. This will create higher tool productivity, because tools will be returned to the tool room as soon as they are not needed by a particular user and another person can use it subsequently. Tool room supervisors should be asked to provide periodic reports on tools requested by the field personnel but not available in the tool room. The supervisor should also collect other information that would help evaluate the efficiency of the tool room operation and adequacy of the existing procedures - average length of wait at the tool room for a craft person, damage to tools returned,

etc. This will ensure that the right tool is in the hands of the tradesperson at the right time.

2. Contents of Tool Kits Issued to Each Craftsperson 20%

   Tools of the trade, frequently used by craftsmen, should be identified on a trade by trade basis and issued to each craft person as tool kits. This way each person will have the opportunity to take care of the assigned tools and be accountable for them. To keep track of such an operation, a tool room supervisor should maintain a record of tools issued for each employee. A craft tool book may be issued with each tool kit to inform the user about the contents of a particular tool kit. To separate the tool kits from tool rooms or warehouses each employee should be given the opportunity of having access to a tool crib or hut.

3. Assignment of Tools not Included in Kits (Small Power Tools) 15%

   To keep the track of tools not included in kits a procedure should cover to whom the tool is issued and for how long. A person borrowing a tool from the a tool room may be, for example, required to leave with the tool room supervisor a badge previously assigned to him.

4. Control of Theft, Loss and Breakage 15%

   To avoid losses and costs of replacement it is necessary to periodically conduct site inventories of small tools and equipment to determine any losses and undertake preventative action in order to avoid further losses.

5. Safety Inspection Frequencies for Tools, Such as Small Power Tools 15%

   All tools during their utilization experience wear and tear. Especially susceptible to wear are small power tools. In order to maintain their safety and reliability frequent inspections of their operational conditions are necessary.

6. Safety Precautions and How to Qualify Personnel to Operate Certain Tools 15%

   All tools improperly used are dangerous. They are responsible for many serious and lasting injuries to the eyes, hands and face. Because of this, all personnel on the construction site should be familiar with safety precautions and comply with safety regulations and operating manuals.

Sub-Total 100%

## 4.13 Management of Temporary Facilities — Weighted Value 3%

Temporary facilities are the facilities that are required for the completion or maintenance of the project but are subsequently removed because these facilities do not form part of the permanent facilities. There are temporary roadways, railroads, parking areas, storage facilities, construction offices, change rooms, temporary service facilities, and safety fencing. In most cases the contractor designs the temporary facilities and is responsible for their maintenance and management.

The management of temporary facilities depends upon the kind of facility and its function on the construction site. To ensure efficient and safe use of temporary facilities the following elements should be considered.

1. Location of Temporary Facilities 35%

   The location of these facilities may have a substantial impact on the construction costs when travel time from them to the main construction area is extensive. All layout of buildings should be made with the objective of reducing lost time due to tool checkout, material checkout, and time checking, as the amount of materials and time lost costs less than does delaying workers who must wait on material.

2. Haul Road Location and Maintenance 15%

   The construction site is the destination of a very large number of passenger and freight trips. There is a need to provide a hard surface for assembling equipment such as cranes, hoists and rolling scaffolds. In order to keep the traffic moving and provide parking space for employees and other vehicles a network of temporary roadways, railroads and parking areas should be built. Because of heavy hauling, construction and temporary access roads need constant attention and maintenance to be kept in satisfactory operational conditions.

3. Prefabrication and Shop Areas 5%

Prefabrication that will take place on site must have an adequate and suitable area set-aside for it. If there is to be an on site shop this must be planned and located in such a way as to enhance productivity.

For example the rebar workers' task will be made easier if a straight production line is created. The steel reinforcement should be stacked above ground level. Money is often wasted on the cleaning of mud splashed reinforcement. Stacking and marking of reinforcement should also be carefully planned. Time is often wasted searching for and removing reinforcement from stacks.

4. Location of Main Offices 5%

The proximity of these offices to the main access points helps create an efficient means of communication. A contract that continues for two or three years may have a peak period during one summer only. Provision should therefore be made for the extension of some of the offices.

5. Water, Power and Sanitary Facilities 5%

With respect to health and safety standards the employer has the responsibility to comply with the provisions of the Occupational Health and Safety Act. Since the general contractor usually furnishes water and power to the subcontractors, power generation to be used and sewage locations should be planned for the whole job and engineered if necessary. Peak utilization should be considered in the planning process.

6. Provide Safety Fencing 5%

A construction project is dangerous and attractive to children, and the law requires that a reasonable effort be made to keep children from dangerous machinery, excavations, and heights. In the case of an urban site adjoining busy streets 8-foot board fences, which are difficult to climb are required. If the construction site is located in rural area and is big (several hundred acres) with no construction visible from the boundaries, it is reasonable to block roads or established paths.

7. Provide Theft Protection 15%

Construction sites are exposed to theft more than any other type of facility. Protection is a trade-off between the cost of protection, particularly the cost of guards, against the cost of losses. There is no universally perfect program because job sites in different locations will require different procedures and devices. However the construction manager should:

- solicit help from law enforcement and fire department officials,
- personally contact neighbours in the immediate area in a friendly way solicit their help,
- control key issuance,
- ensure that gates to the project area are locked or guarded when not in use,
- make sure that storage sheds or fenced areas are used to properly secure all tools and equipment,
- make sure that all equipment is marked with permanent identification,
- install proper lighting
- install alarm systems where feasible,
- encourage security suggestions from employees,
- report theft and vandalism promptly.

8. Construction Camp Planning 15%

The Camp area should be planned with due regard to the existing road and utility network, and should take into account subdivisions, schools, shopping centers, medical and emergency services, and the community activities of the present and anticipated future residents of the area. The public acceptance of the completed facility may be greatly and positively influenced by the care and effectiveness with which such planning is done. In a remote area with little existing development, similar advance provision should be made for the operating personnel of the completed project. In such a situation there will be less concern for integration into the existing community, but correspondingly greater concern for the character of the community being established. The probable future development of the region must be considered, including the effect of the contract facility under construction.

Sub-Total 100%

## 4.14 Scaffolding Management — Weighted Value 3%

Scaffolding is used for many purposes during construction. It may be used to support working platforms, stairways, hoists, trash chutes and more recently has been used to support shoring.

Erecting and maintenance costs are usually high - 15% of piping manhours or $25 per frame per month in case of gas plant construction. Along with the high scaffolding costs a large number of building regulations must be taken into consideration in scaffolding management. However several of these are similar in context and differ only in detail.

Due to the high cost of scaffolding and tough safety requirements there are six important elements which should be identified in scaffolding management.

1. Manage to Have Scaffolding Once in One Place — 30%

   The relatively high cost of erecting is the main reason why all works which need scaffolding should be done using the same scaffold in one particular place, especially where use of rolling scaffold is limited by construction conditions.

2. Construct in Accordance With Regulations — 20%

   It is important to emphasize that compliance with Occupational Health and Safety Act regulations is necessary by law. It is impossible to provide specific circumstances which lead to scaffold-related accidents in the field; only the broadest caution - use only safe procedures and be alert at all times - can prevent accidents. Therefore, it is recommended that appropriate engineering specifications for type and use of equipment always be followed whether or not their current versions are promulgated into OHSA regulations.

   Further, almost all scaffolding manufacturers publish and make freely available safety rules and instructions for their products. Following these publications can further promote safety and reduce hazards.

3. Responsibility of Construction, Maintenance and Inspection — 20%

   Building and safety regulations are made up of rules relating to the inspection of scaffold materials by a competent person, and that no scaffold shall be erected, altered, added to, or dismantled except under the immediate supervision of a competent person. Further, such work shall be carried out by competent workmen experienced in the work.

   No scaffold is to be used unless it has been inspected in the

previous seven days by a competent person, and must also have been inspected following exposure to weather, which could have affected the strength and stability of the scaffolding. A report of the results of this type of inspection has to be recorded in the prescribed manner.

After each inspection scaffolds should be colour coded with flags or tags to facilitate quick identification of safe and unsafe scaffolds. For example, a safe scaffold with a green flag and a sign "ACCEPTED FOR USE" may be implemented, and for unsafe scaffolds a red flag with a sign "DO NOT USE".

The Alberta Occupational Health and Safety Act contains special regulations governing testing and certifying scaffolds used to carry load of more than 3.6 kilonewtons per square metre, suspended, and swingstage scaffolds. These scaffolds should be tested and certified by professional engineers.

4. Materials for Scaffolding 10%

Another requirement of the building and safety regulations is that materials for scaffolding shall be sound. There is a duty to keep unsound material apart from that which is sound. Metal parts are to be free from corrosion. The use of defective or irreparable material is prohibited.

5. Scaffolding Maintenance 10%

The Occupational Health and Safety Act requires employers to ensure that all equipment used on a work site:

a) is maintained in a condition that will not compromise the health or safety of workers using or transporting the equipment,

b) will perform the function for which it is intended or designed,

c) is of adequate strength for that purpose, and (d) is free from patent defect.

6. Reporting of Defects 10%

Provisions of the OHSA require that where a worker has equipment under his control that does not comply with foregoing element, he shall forthwith remove it from service.

Workers should be instructed to report defects immediately in order to prevent unsafe use and begin repairs immediately.

Sub-Total 100%

# 5.0 PROJECT RATING

In order to evaluate the performance of a construction project, each element of the 14 basic sections, previously discussed in Section 4.0 of this report, will be graded or given a score by the auditor. Auditors are encouraged to apply (with modifications if they so deem) Forms 1 to 14.

The project overall score, which is based on another weighting is then summarized using Form 15.

Before applying the suggested criteria, industry practitioners need to validate the construction project evaluation methods that are suggested in this report. The object of the validation of our criteria before applying it is to produce an overall evaluation score, reflecting how the construction management team assesses the performance of the project.

# FORM 1 – COST MANAGEMENT

## (Weight Value 6%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Establish Control Budget Based on a Code of Accounts (WBS). | 40% | | |
| 2. Continuous Monitoring of Project Expenditures Against a Control Budget. | 20% | | |
| 3. Detailed Code of Accounts. | 5% | | |
| 4. Forecast of Final Cost in Each Detailed Account Code. | 10% | | |
| 5. Trend and Change Order Procedure. | 10% | | |
| 6. Updates to Budgets and Forecast based on Approved Trends and Change Orders. | 10% | | |
| 7. Detailed Cost Report. | 5% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 2 – SCHEDULE MANAGEMENT

## (Weight Value 10%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Integrated Engineering, Procurement and Construction Schedule based on CPM Network Theory. | 30% | | |
| 2. Successive Levels of Construction Schedules.<br><br>Consistent with the Project Master Schedules. | 10% | | |
| 3. Construction Weekly Work Plan. | 10% | | |
| 4. Construction Progress Curve. | 15% | | |
| 5. Construction Manpower Histogram. | 15% | | |
| 6. Project Key Dates and Milestone Schedule. | 5% | | |
| 7. Schedule Updated and Progressed at Regular Intervals. | 10% | | |
| 8. Schedule Weekly and Monthly Reports. | 5% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 3 – WORK PLANNING

## (Weight Value 12%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Definition of the Scope of the Work Package to be Executed. | 25% | | |
| 2. Work Package Prerequisites Identified and Completed. | 25% | | |
| 3. Planning Work Packages with Safety Considerations. | 10% | | |
| 4. Work Plans Consistent with the Project Construction Schedule. | 10% | | |
| 5. Use of Effective and Efficient Construction Methods. | 5% | | |
| 6. Defined Resource Requirements (Manpower) for the Work Package. | 5% | | |
| 7. Identified Cost Codes to be Charged Against When Coding Time Cards. | 2% | | |
| 8. Identification of Who is Responsible for a Work Package. | 8% | | |
| 9. Checking Work Progress While Identifying and Solving Unforeseen Problems. | 10% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 4 – PROGRESS AND PRODUCTIVITY

## (Weight Value 10%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Accurate Measurement of Physical Percent Complete of Construction Activities. | 30% | | |
| 2. Regular Progress and Productivity Measurement Intervals. | 10% | | |
| 3. Forecast Final Construction Manhours. | 10% | | |
| 4. Calculate Productivity Factors by Comparing the Earned Manhours (Progress) versus Actual Expended Manhours. | 20% | | |
| 5. Regular Progress and Productivity Reviews and Reports to Construction Management. | 20% | | |
| 6. Accurate Measurement of Expended Manhours per Construction Activity. | 10% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 5 – QUALITY MANAGEMENT

## (Weight Value 8%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Level of Quality Included in Design or Plan. | 30% | | |
| 2. Material Control System. | 15% | | |
| 3. Competence of Workers and Supervisors. | 15% | | |
| 4. Management Support. | 10% | | |
| 5. Pride of Workmanship. | 10% | | |
| 6. Timing of Quality in Project Life Cycle. | 5% | | |
| 7. Non-conformance Reporting and Inspection. | 5% | | |
| 8. Role of QC Inspector. | 5% | | |
| 9. Subcontractor Monitoring. | 5% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 6 – SAFETY MANAGEMENT

## (Weight Value 8%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Safety in Design. | 20% | | |
| 2. Training of Workers and Supervisors. | 20% | | |
| 3. Planning for Methodology and Hazards. | 20% | | |
| 4. Safety Program. | 10% | | |
| 5. Management Support. | 10% | | |
| 6. Safety Training. | 5% | | |
| 7. Maintenance Program. | 5% | | |
| 8. Emergency Preparedness. | 5% | | |
| 9. Records and Statistics. | 5% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 7 – ORGANIZATION

## (Weight Value 7%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Personnel Selection Methods. | 30% | | |
| 2. Organization and Reporting Structure. | 25% | | |
| 3. Home Office Construction and Engineering Liaison. | 15% | | |
| 4. Staffing and De-Staffing Plans and Procedures. | 15% | | |
| 5. Training Programs for First Line Supervisors. | 15% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 8 – LABOUR RELATIONS

## (Weight Value 7%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Workforce Planning. | 35% | | |
| 2. Apprenticeship and Training Programs for Craft Labour. | 25% | | |
| 3. Grievance Handling. | 20% | | |
| 4. Workforce Recruitment. | 10% | | |
| 5. Labour Relations Coordinator. | 10% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 9 – MATERIALS MANAGEMENT

## (Weight Value 12%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Materials Planning. | 30% | | |
| 2. Purchasing. | 15% | | |
| 3. Receiving and Issuing. | 15% | | |
| 4. Inventory Management. | 25% | | |
| 5. Materials Management Systems. | 15% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 10 – SUBCONTRACT ADMINISTRATION

## (Weight Value 6%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Subcontract Planning. | 40% | | |
| 2. Bidding and Awarding. | 10% | | |
| 3. Subcontractor Coordination. | 40% | | |
| 4. Acceptance. | 10% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 11 – MANAGING CONSTRUCTION EQUIPMENT

(Weight Value 4%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Equipment Supply and Work Schedule. | 15% | | |
| 2. Right Person-Right Machine-Right Job Concept. | 20% | | |
| 3. Crew Continuity and Motivation. | 20% | | |
| 4. Development of Equipment Availability and Utilization Data. | 10% | | |
| 5. Equipment Safety Checklists. | 15% | | |
| 6. Equipment Maintenance Program and Facilities. | 20% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 12 – MANAGEMENT OF CONSTRUCTION TOOLS

(Weight Value 4%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Location of Tool Rooms. | 20% | | |
| 2. Contents of Tool Kits Issued to Each Craftsperson. | 20% | | |
| 3. Assignment of Tools not Included in Kits (Small Power Tools). | 15% | | |
| 4. Control of Theft, Loss and Breakage. | 15% | | |
| 5. Safety Inspection Frequencies for Tools, Such as Small Power Tools. | 15% | | |
| 6. Safety Precautions and How to Qualify Personnel to Operate Certain Tools. | 15% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 13 – MANAGEMENT OF TEMPORARY FACILITIES

(Weight Value 3%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Location of Temporary Facilities. | 35% | | |
| 2. Haul Road Location and Maintenance. | 15% | | |
| 3. Prefabrication and Shop Areas. | 5% | | |
| 4. Location of Main Offices. | 5% | | |
| 5. Water, Power and Sanitary Facilities. | 5% | | |
| 6. Provide Safety Fencing. | 5% | | |
| 7. Provide Theft Protection. | 15% | | |
| 8. Construction Camp Planning. | 15% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 14 – SCAFFOLDING MANAGEMENT

## (Weight Value 3%)

| Activities | Weight | Grade (1 – 10) | Value (Grade x Weight) |
|---|---|---|---|
| 1. Manage to Have Scaffolding Once in One Place. | 30% | | |
| 2. Construct in Accordance With Regulations. | 20% | | |
| 3. Responsibility of Construction, Maintenance and Inspection. | 20% | | |
| 4. Materials for Scaffolding. | 10% | | |
| 5. Scaffolding Maintenance. | 10% | | |
| 6. Reporting of Defects. | 10% | | |
| TOTAL VALUE FOR COST | 100% | | |

# FORM 15 – PROJECT EVALUATION SHEET

Project: _____ Owner: _____

Location: _____ Contractor: _____

Contract Type: _____ Capital Cost: _____

Duration: _____

| Criteria | Weight | Value (Form 1 – 14) | Score (Weight x Value) |
|---|---|---|---|
| Cost Management Sub-Total | 6% | | |
| Schedule Management Sub-Total | 10% | | |
| Working Plan Sub-Total | 12% | | |
| Progress and Productivity Sub-Total | 10% | | |
| Quality Management Sub-Total | 8% | | |
| Safety Management Sub-Total | 8% | | |
| Organization Sub-Total | 7% | | |
| Labour Relations Sub-Total | 7% | | |
| Materials Management Sub-Total | 12% | | |
| Subcontract Administration Sub-Total | 6% | | |
| Managing Construction Equipment Sub-Total | 4% | | |
| Management of Construction Tools Sub-Total | 4% | | |
| Management of Temporary Facilities Sub-Total | 3% | | |
| Scaffolding Management Sub-Total | 3% | | |
| TOTAL PROJECT | 100% | | |

# 6.0 CONCLUSIONS

The project evaluation tool can be used by conducting a series of interviews with a group of construction managers who are managing current or recently completed projects. The results of the interviews and the auditors' subsequent evaluations on each of the construction management criteria is to produce an overall evaluation score, reflecting how the auditors assessed the performance of the project and its construction manager. The project scores should be used as a check on the thoroughness of the construction managers and individuals as well as used as an appraisal of the project itself.

Using our proposed construction project evaluation criteria, the auditor can evaluate the overall performance of a project. In our opinion, a major construction project must score at least 75% to be regarded as successful.

This tool will also enable construction teams to identify areas of strength and areas for improvement.

# 7.0 RECOMMENDATIONS FOR IMPLEMENTATION

From the analysis made, there is no question that improvements in productivity can and should be made. The opportunity is tremendous but like anything, it must be initiated. Historically, because of the other pressing issues like, “will the job go ahead?”, “when will approval come?”, the problem of getting started on a productivity improvement program gets delayed. Even though the savings can be in the millions of dollars, they can only happen if the recommendations are put in place. In order to put them in place, three stages are required:

Stage 1 (Planning Phase) - During the planning phase on a project, a qualified construction presence must be on the project to initiate this program in-house and carry it forward to the unions and EPC contractors. A good start for any construction project is, from the outset, to define criteria for doing the job properly. Measuring success or defining a good project is extremely important. It allows actual performance to be measured against a previously defined baseline. For this study, in Section 7.1, we included a list of major issues that define a “good job” and positively impact labour productivity. The content of this Section might be the basis or supplement of the auditing program explained earlier in Sections 4.0 and 5.0.

Stage 2 (Execution Phase) - During the execution phase, work with execution contractors and the owner to carefully monitor and implement the plan.

Stage 3 (Evaluation Phase) - Perform ongoing audits to ensure the plan is working and on stream.

This would entail two or three people throughout the project. A small investment for the opportunity.

## 7.1 Criteria for Doing the Job Properly

Measuring success or defining a good project / job is extremely important. It allows actual performance to be measured against a previously defined baseline. For this study, a list of major issues that define a “good job” and positively impact labour productivity were identified.

The previous Sections 4.0 and 5.0 are indicators as to how a project is actually performing at a point in time of the audit. This section identifies the possible shortcomings that, when evaluated, should indicate what management emphasis should be dealt with in order to improve the score on Form 15.

Investigating and thoroughly researching the list and its components is outside the scope of this phase of our mandate. The criteria for doing a "good job" is listed below.

## CRITERIA FOR DOING A "GOOD JOB"

- DOING THE JOB PROPERLY INVOLVES THE CORRECT …
  - Leadership
  - Contracting Strategy
  - Schedule
  - Skills of Workforce
  - Training
  - Tools
  - Construction Equipment
  - Planning Methods
  - Procedures
  - Communication
  - Meetings
  - Skills of Supervision
  - Amount of Supervision
  - Understanding of Regulations
  - Orientations
  - Investigations / Reporting
  - Audit and Inspection
  - Attitudes

## ◆ LEADERSHIP

- Senior Management Involvement
- Safety Responsibility Defined
- Reward Tied to Performance
- Company Light Duty Policy
- Knowledgeable / Concerned
- Formal Safety Program
- Company Safety Policy
- Site Specific Program
- Company Drug Policy
- Supportive / Involved
- Professionalism

## ◆ CONTRACTING STRATEGY

- Lump Sum
- Cost Reimbursement
- Partnering / Alliance
- Risks and Responsibilities
- Rewards and Incentives

## ◆ SCHEDULE

- Allows Orderly Development
- Allows Time for Planning
- Minimizes Overtime
- Considers Time Off
- Time for Training
- Optimizes Shift
- Flexibility
- Long-Lead Items
- Regular Updates and Monitoring
- Corrective Action

- SKILLS OF WORKFORCE
  - Questionnaire Establishes Strength
  - Strengths Matched to Weaknesses
  - Identifies Job Requirements
  - Capabilities Verified
  - Knows Regulations
  - Buddy System

- TRAINING
  - Investigation Training
  - Work Method Training
  - Has Safety Training
  - Equipment Training
  - Planning Training
  - Scaffold Training
  - Rigging Training
  - Has Craft Skills
  - Hazard Training
  - Tool Training

- TOOLS
  - Properly Maintained
  - Proper for the Job
  - Meets Regulations
  - Owned / Rented

- CONSTRUCTION EQUIPMENT
  - Inspection Requirements

- Properly Maintained
- Meets Regulations
- Properly Utilized
- Proper for Job
- Owned / Rented

◆ PLANNING METHODS

- Planning Identifies Communication
- Planning Identifies Procedures
- Planning Identifies Equipment
- Planning Identifies Materials
- Planning Identifies Scaffold
- Planning Identifies Training
- Planning Identifies Hazards
- Planning Manages Hazards
- Planning Done in Advance
- Planning Identifies Skills
- Planning Identifies Tools

◆ PROCEDURES

- Are Reviewed with Worker
- Are Available to Worker
- Proper for Type of Work
- Meets Regulations
- Are Verified

◆ COMMUNICATION

- Proper Atmosphere Established
- Plan for Communication
- Down to the Workforce

- Up from the Workforce
- Audit its Working
- Encouraged
- Written
- Verbal

◆ MEETINGS

- Feedback Communicated
- Participation Solicited
- Purpose Established
- Actions Tracked
- Agenda in Place
- Actions Given
- Free Dialog
- Short

◆ SKILLS OF SUPERVISION

- Assessed by Questionnaire
- Trained in Requirements
- Trained in Regulations
- Trained in Procedures
- Capabilities Verified
- Trained in Planning
- Trained in Methods
- Related to Project
- Related to Trade
- Attitude

◆ AMOUNT OF SUPERVISION

- Related to Hazard Management

- Based on Worker Capability
- Based on Complexity
- Time to Supervise
- Not on the Tools Supervisor
- Clear Directions

◆ UNDERSTANDING OF REGULATIONS

- Regulations Available to Supervisor
- Regulations Available to Workforce
- Regulations Available at Jobsite
- Regulations Understood
- Regulations Monitored
- Regulations Reviewed
- Regulations Read

◆ ORIENTATIONS

- Related to Requirements
- Related to Hazards
- Related to Craft
- Related to Job
- Professional

◆ INVESTIGATION / REPORTING

- Proper Personnel Review
- Learnings are Sought
- Records Maintained
- Learnings Shared
- Formal

◆ AUDIT AND INSPECTION

- Action Plans Established

- Action Plans Followed Up
- Results Communicated
- Audit Against Criteria
- Program is Working
- No “Witch Hunts”

◆ ATTITUDES

- Promotion of Positive Safety
- Positive Reinforcement
- Verified at Orientation
- Verified at Workplace
- Verified at Tailgates
- Corrective Action
- Checks in System

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