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MANAGING INTERNATIONAL ASPECTS OF ENGINEERING RISKS

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ABSTRACT

The need for effective Risk Management at the engineering stage of the project life cycle is critical for a project's success and can prevent disputes and increase profits for both owners and contractors. The engineering stage of a project, while not the most costly, can impact the budget and schedule of subsequent, more costly phases. Multinational contracting firms compete globally for projects, making price competition fierce, lowering profit margins, and making cost a key distinguishing factor. In addition, owners have high expectations of contractors and are transferring ever more project risk to contractors. To increase profit, execution plans are adding an international component to project risks by outsourcing detailed engineering to offshore organizations that use less expensive labor to perform engineering – commonly referred to as "low-cost centers." In addition to managing engineering risks such as design coordination, changes, errors and omissions, staff availability, new technology and roles and responsibilities, contractors magnify these risks by using low-cost centers. Because of these new realities, implementing a comprehensive Risk Management system from the earliest planning stages has become essential for every EPC contractor to minimize risk at the engineering phase.

KEYWORDS

Risk, Management, Engineering, Outsourcing

1. INTRODUCTION

In the current competitive global market, controlling and minimizing project costs is a challenge shared by all parties: owner/employer, engineer, construction manager and contractor. The engineering scope of a project, while not the most costly phase of work, if not properly managed can impact subsequent, more costly, project phases. Ineffective management of risk at the engineering stage greatly increases the potential for severe negative impacts to the project budget and schedule, which inevitably result in disputes. The risks associated with performing engineering on a project are further magnified when an international perspective is included in the project execution plan; these risks must be well managed to ensure a successfully completed project.

Engineering risks, if not managed, logically impact the next stages of a project, including procurement, fabrication, construction and startup, where most of the project costs are incurred. Among the major engineering risks to be managed are reliance upon owner-supplied information, design, schedule, coordination of design, changes, design errors and omissions, availability of skilled staff, new technology and various parties' roles and responsibilities. A common international component of engineering execution plans is the outsourcing of detailed engineering, by the contractor's home office engineering, to an offshore or subsidiary engineering organization. Offshore or subsidiary firms typically use less expensive labor to perform portions of the detailed engineering at a lower cost and are commonly referred to as "low-cost centers." Overlaying use of a low-cost center, a risk that can have significant impact on project budget and schedule, onto the typical major engineering risks that must be managed magnifies the potential for failure and further justifies the need for a comprehensive Risk Management program from the earliest planning stages.

This paper emphasizes the critical importance of managing risk at the engineering stage for a project's success, sets forth the fundamental systematic steps to be considered in Risk Management campaigns and offers insights to engineering firms, contractors, construction managers and owners/employers involved with international construction projects to better identify, assess and mitigate risks attributable to the management of engineering.

2. MANAGING ENGINEERING RISKS

Managing risk at the engineering stage of the project life cycle is critical for a project's success. Large multinational engineer-procure-construct (EPC) contracting firms increasingly compete globally for projects, making competition fierce. Since these multinational firms are often similar in capabilities, cost has become a key distinguishing factor between competing contractors, thus increasing price competition and lowering contractor profit margins. Additionally, project owners/developers have high expectations of EPC contractors and are using lump sum turnkey (LSTK), guaranteed maximum price and other hard-dollar contracting methods to transfer more project risk to the contractor. Because of these new realities, implementing a Risk Management system to minimize risk at the engineering phase has become essential for every EPC contractor.

With increased competition, multinational EPC firms are being awarded contracts with tight schedules and budgets, and are seeking ways to minimize costs through the scopes of all project phases, including engineering. Advancements in telecommunications, electronic/computerized project tools and other project management methods allow these firms to use company resources and infrastructure wherever it is located to compete for and execute work anywhere in the world. Frequently, use of a low-cost center to perform detailed engineering is a method practiced by multinational EPC firms to minimize costs and is included in the execution plan for engineering.

Using a low-cost center to perform engineering scope heightens the need to manage the major engineering risks, including the coordination of design, changes, design errors and omissions, availability of skilled staff, new technology and various parties' roles and responsibilities.

3. FIVE GOALS FOR RISK MANAGEMENT

The principal objectives of Risk Management for EPC contractors can be stated in five goals:

1. Cost and schedule estimates are correct to an acceptable level of accuracy.
2. Execution risks are identified and evaluated, beginning with the question: Is the execution plan appropriate for the specific project?
3. Contract risks are identified and evaluated, including the analysis of:
    a. Compliance with legislative/agency or corporate legal requirements,
    b. Contract structure/project delivery method/contract organization risks, and
    c. Scope of work/performance standards/deliverables.
4. Action plans are developed to avoid or mitigate impacts from the risks that were identified.
5. A reliable Risk Management performance system is in place to monitor and report on action plans during each stage of the process: project planning, bid tender, contract award and execution of the project.

4. THE CONTRACTOR'S RISK MANAGEMENT CAMPAIGN

The contractor's goals in managing risks on large projects necessitate performing specific risk identification, risk evaluation and Risk Management steps when developing its subcontracting and execution plans, especially when international components are part of the plan. Ten major Risk Management steps are detailed in the following paragraphs.

4.1 Define Contractor Project Success

For most contractors, the benchmark for project success is achieving the as-sold margin. This benchmark includes the notion that different profit margins are acceptable in different industries serviced by a contractor and even on different projects within the same industry. Contractors expect to be paid to accept risk; from a contractor's perspective, the more risk there is to an undertaking the more reward it should receive.

The competitive international environment has led to diminished margins that leave little room for error. Projects are bid and sold at very low margins, sometimes just to keep staff employed, and then low-cost centers are utilized to increase or meet profit goals.

4.2 Acknowledge Contractor Realities

The contractor typically enters the project after the owner has already defined the project delivery method, contract form and other contracting variables. Bids are often estimated by the owner prior to sending out bid packages, and there can be significant competition for each contract. Contractor Risk Management is also affected by the fact that contractors almost always have considerably less time to evaluate a project and prepare a plan, schedule and cost estimate than the owner had. The contracts can be thousands of pages long when the referenced standards and specifications are included. These contractor realities, as shown in Table 1 below, must be acknowledged in the process of identifying and managing project risks.

Table 1: Contractor Realities

Contract Variable	Owner	Contractor
Scope Definition	Decided	Accept/negotiate clarifications
Cost	Estimated	Offers in competition
Schedule	Estimated or fixed	Offers in competition
Contract Form	Decided/may accept alternative offers	Accept/propose alternative
Terms and Conditions	Draft contract included in bid package	Accept/negotiate changes
Planning Period	2 – 5 years	30 – 120 days

Owners have increasingly higher expectations of contractors, and contractors tend to accept owners' terms and conditions in order to be awarded a contract, sometimes without protecting contractual rights or having a Risk Management plan in place.

4.3 Understand the Contract

In order to identify, evaluate and manage risks in development of a competitive but achievable bid and in execution of a successful project, the contractor must understand the relationships between all parties executing work in connection with the project. The owner defines the project delivery method and parcels the tasks required to design and construct the facility to its optimum financial benefit. Contract liability requires having a contract with the party alleging breach (contract privity). Thus understanding the project contracting structure (who has a contract with whom) *completely* is critical to evaluating where claims or execution difficulties might arise.

EPC contractors, particularly in the engineering phase, rely heavily upon information and deliverables from a third party with whom they have no contract remedy because they have no contract.

4.4 Understand the Entire Scope of Work in the Contract

Recognizing that the scope of work is literally thousands of pages in some complex projects, it is perhaps understandable that the first time a dispute arises is sometimes also the first time the scope of work is carefully examined by either the owner or the contractor. Since owners most often write scopes, not understanding the entire scope is a risk that a contractor cannot afford to accept.

The mantra promoted by the management of many contractors, "Read the full contract," is based upon the useful concept of full understanding but, in reality, often cannot be achieved by any one person due to the volume of documents. While there are some parts of the contract that should be read by everyone working on the project, the majority of the contract needs to be broken into digestible elements for the contractor team to read and understand. This is done by:

- Identifying the parts of the entire contract, including referenced standards and procedures;
- Collecting copies of all referenced documents/applicable codes, etc.;
- Using a matrix to organize the scope elements, identifying who needs which parts; and
- Distributing the contract parts to the designated parties for careful reading and understanding.

In addition to furthering the understanding of the project scope and required deliverables, reading and understanding the entire contract allows the costs associated with owner- or location-driven codes and specifications to be captured and included in the tendered bid.

Location-driven codes and specifications, especially for international projects, are too often the source of errors, delays and disputes because incorrect assumptions are made as to what industry standards would be acceptable.

4.5 Define the Deliverables

Contractors are very project-oriented and typically think in terms of deliverables. All of the execution deliverables and contract deliverables need to be identified by the contractor and carefully detailed, showing to whom the deliverables are due and from whom they are due.

This exercise shows the contractor clearly:

- What it needs in order to perform any engineering that the contract does not explicitly state the owner would provide, including approvals and reviews (i.e., contract deliverables).
- What deliverables the contractor has to rely on third parties to provide to complete engineering, meaning that there may be no entitlement to impacts if they are not delivered.
- What engineering deliverables the contractor is to provide to third parties in order for those third parties to perform their work scopes, meaning that a claim may originate through the owner for failure to coordinate with those third parties.

4.6 Communicate the Contract Form

Part of the justification used by technical staff of the contractor for not reading the contract is that it is full of legal terms and is unclear to them. Forcing them to read it will only mean they have read something they do not understand. Thus, some contractors provide a plain language dissertation of the contract to the project team. Unfortunately, this is often done by an overburdened legal staff after the project is awarded, which is likely to be too late. As a consequence of not reading the contract, a project team is often surprised to discover what they must perform.

A review of key entitlements and liabilities in simple English is important to the staff executing the project and administering the contract. Without understanding how the client can access financial guarantees or withhold payment, the technical staff manning the project cannot protect against such risks.

4.7 Identify the Soft Scope

Many claims result from one party not understanding that it is to perform a task or not understanding the standard that applies to its performance of a particular task. Words such as “verify,” “coordinate,” “collaborate,” “confirm” or “quality,” for instance, create an immeasurable standard for performance that does not clearly state the level of responsibility for the task. Another soft scope issue on international projects is adherence of engineering to local industry standards and requirements, as these may not be coordinated with in-house design, procurement and field work. These soft scope issues are often included in owner contract forms and scopes of work. However, when there is a dispute or a question of entitlement, these phrases are looked upon to validate or invalidate a party’s position.

The contractor's job is to identify soft scope and seek or provide clarification as to its meaning before the contract is executed. The criticality of soft scope phrases will vary and thus the potential impact to project success must be evaluated systematically. Without doing this, the estimate for cost and schedule cannot be relied upon.

4.8 Identify the Risks

The previous steps have helped identify the execution and contract deliverables from and to the contractor, the liabilities connected with the contract and how these liabilities are triggered when deliverables are not provided as required, and also the soft scope. With that combined information, the contractor is ready to identify the risks within a particular project environment.

Risk identification seems to be the most difficult step in the entire Risk Management process for contractors. The contractor, as does the owner, strives to avoid or mitigate impacts to project success. Success defined by the contractor as its as-sold margin. However, several factors make risk identification more difficult for contractors than for owners. These include:

- Contract form and terms already prepared and voluminous
- High turnover in staff as compared to most owners
- Project teams not typically the same personnel each time
- Limited timeframe to review, as bid preparation period is prescribed by owner
- Lack of familiarity with project site
- Stiff competition, and frequent clarification requests to owner may be viewed as irritating

With these realities facing contractors, the risk identification system must be simple and efficient. Also, because of the competitive nature of the bidding marketplace and the transparency of the bidding process, key risks cannot be overlooked, so the system needs to be thorough and accurate.

Typically, contractors use one of three methods or a combination of those methods to identify risk. Each method has its own pros and cons, as shown in Table 2.

Table 2: Contractor Risk Identification Methods

Identification Method	Pro	Con
Checklist	Thorough; review consistent issues	Being thorough usually takes a long list; cumbersome to use alone during execution
Brainstorming	Fast, dynamic; can change items reviewed	Relies on knowledge of participants to raise risk concerns
Computer Models	Provide detailed quantitative data	Long time required to input data may affect application; projects are specific collections of risk, and models rely on other projects to predict outcomes of specific risks

The method employed by The Nielsen-Wurster Group, Inc. is a mixture of techniques collectively called Structured Brainstorming, which uses checklists to orient and structure the thinking of the brainstorming team. While computer models offer interesting prospects, the variety of specific risks a contractor faces on a project and the timetable the contractor is typically provided in which to tender a bid limit the usefulness of these models to contractors.

4.9 Evaluate the Risks

After the risks have been identified, the potential impact of each risk needs to be evaluated so the risks with the greatest potential impact are addressed with the most attention and resources, with the cost and schedule estimates reflecting those extra measures. Various techniques are used by contractors to evaluate risk, all leading to the same two parameters – likelihood of occurrence and severity of impact upon the project.

A critical mistake made by many contractors is struggling to develop quantitative potential impact numbers in inappropriate circumstances. The time spent developing quantitative exposure numbers for identified risks at the bid tender stage often means sacrificing the breadth of the risk identification and evaluation of other risks. In most cases, it is not possible to precisely determine the potential financial impact of any risk on the project at the bid stage. A qualitative method recognizes the time limitations and other objectives that the contractor covers in its Risk Management process.

4.10 Develop Action Plans and Continue Risk Management

The contractor performs its Risk Management steps based upon potential impact to the specific project. Action Plans are developed to best address the nature of each risk identified, placing more resources on the more critical risks. Action plans for risks that show a high likelihood for occurrence should not focus on prevention but rather on mitigation. Action plans for risks with a severe impact potential but a low likelihood for occurrence should focus on prevention.

The Contractor also faces the concerns of changing risks and new risks during the Project's execution and must review its profile of risks periodically to validate and revise current risk priorities, groups of identified risks and Action Plans.

5. PROJECTS WITHOUT EFFECTIVE RISK MANAGEMENT

Examining several multinational construction projects, each of which experienced cost overruns and schedule delays rooted in mismanagement at the engineering phase of the project life cycle, resulting in major disputes, demonstrates the need for effective engineering Risk Management. These projects were located in the Middle-East, Asia, South America, the United States (US) and Europe. Execution of these projects also included the international perspective of outsourced detailed engineering to a low-cost center. For each project, specific difficulties encountered are explained, management successes and/or failures are discussed, and impacts to subsequent phases of work are related back to the engineering phase.

5.1 Middle-East (ME) – LSTK Power Plant

The owner, a ME Power Authority contracted with a ME/US/European group, with construction to be performed by an ME general contractor and the detailed engineering subcontracted to a US multinational firm. The engineering firm had a fixed-price contract for detailed design utilizing computer modeling. Most of the engineering was performed at the home office in the US, with some architectural, structural and piping scope allocated to a low-cost center in Asia, supervised by home office discipline leads. Drawings were sent to the ME for construction and changes were made at the engineering firm's office in the ME and at the site. Problems began as the general contractor did not comprehend the computer technology utilized for design and then, along with the owner, required continuous changes, provided late and changed equipment data, executed late procurement and revised the overall plant layout. Initially, the engineer was able to accommodate the changes but, as the number of changes expanded, coordination with the Asian office became cumbersome and inefficient and was not effectively managed. All engineering and changes were completed at costlier rates in the US offices, without reimbursement from the general contractor. Impacts were experienced by both the engineer and general contractor – the engineering budget tripled, the original engineering duration was delayed, field work was reperformed by the general contractor, backcharges were issued, and the contract was terminated by the engineer. Had the risks experienced by the engineer been managed, the impacts could have been avoided or mitigated.

5.2 Asia – LSTK Bulk Pharmaceuticals Plant

The owner, a US pharmaceutical firm, contracted with a US EPC firm to design and construct a bulk pharmaceutical process plant in Asia. The EPC firm performed the bulk of its engineering in the US and outsourced general site and utilities design to its low-cost Asian engineering partner. The EPC engineering firm utilized another Asian partner for construction. Coordination between offices was a risk that had to be managed and was not. The EPC firm did not coordinate the design interface between offices. Some design was not complete when transmitted between offices, was not completed in a timely manner and surprised the parties when it was erroneous, requiring reengineering and remedial work to complete the design. The internal problems were exacerbated by owner-initiated changes, which then resulted in design conflicts and coordination problems in the field, i.e., pipe flanges that did not meet. Had the coordination risk been managed, the impacts could have been mitigated or avoided.

5.3 South America – LSTK Natural Gas Processing Plant

The owner, a South American (SA) corporation, contracted with a partnership of a US EPC firm and a local SA engineering firm to design, construct and commission a natural gas processing plant. The initial process engineering was performed at the EPC contractor's home office in US. Detailed engineering was performed by the local SA engineering firm, which also served as the low cost center and was to ensure that local codes and requirements were met for safety and operation – also required by the contract. The owner issued changes to process design during the detailed design phase performed in SA and the SA engineering firm made changes without coordinating with its partner in the US. This risk was not managed to coordinate design and verify that state-of-the-art and local code requirements were being met. The owner continued to require late changes to the control and operation of the plant well after mechanical completion and these late changes had to be made by the EPC contractor's home office in the US at costlier labor rates. Impacts were experienced by the partnership that doubled the engineering budget, the field support budget and overall construction duration and costs. Had the risks experienced by the partnership been managed, the impacts could have been avoided or mitigated.

5.4 United States – LSTK Unit Addition at US Refinery

A refinery in the US, owned by a US petrochemicals firm, contracted with a US EPC contractor to design and construct an additional unit, with basic engineering performed in the US home office. The structural, piping and electrical design work was outsourced to a low-cost center subsidiary in Asia, while the major equipment vendor was also from Asia. Impacts to the project were rooted in the fact that the overall design was not coordinated by the project manager or by discipline managers in the US home office. In addition, the engineering performed in Asia was similarly uncoordinated between offices and disciplines. The outsourced engineering design packages were completed late, overdesigned to wrong US codes and then required reengineering by the US office. These problems were compounded by the fact that the major equipment vendor did not supply information in a timely manner to the US for coordination. Changes to the steel delayed supply and the fabrication vendor, and resulted in out-of-sequence delivery. Installation contracts had to be let as time and material because no subcontractor would bid the work. All these impacts resulted in a late project with cost overruns in engineering and field work and delays to project completion, exposing the EPC to liquidated damages. The risks that required management on this project were all within the control of the EPC contractor, especially coordination of the design between offices and disciplines. Had those risks been managed, the impacts could have been avoided or mitigated.

5.5 Europe – LSTK Cogeneration Plant

The European power-operating firm contracted with a US/European EPC firm to construct a cogeneration plant. Due to cost and time considerations, the execution plan called for completion of the bulk of the engineering in the US. The major design consideration for the project was that the European country had a regulatory authority with strict specifications for pressure pipe and vessels. The EPC contractor had an inefficient interface between the US and European engineering groups that impacted the integration of local codes and regulations into the design. As a result, the design was produced with US standards that were not compliant with European codes. This caused significant time and cost overruns due to reengineering of the plant. In addition, the material and equipment procured did not meet the European standards, forcing re-procurement. The engineering duration of work doubled, while the overall actual duration to design and build the plant overran the original plan by an additional two years. The risk to the engineering scope of this project was the internal interface of engineering and compliance with local codes, which, if properly managed, would have mitigated or avoided the impacts to the project budget and schedule.

6. CONCLUSION

Impacts experienced during engineering, procurement, fabrication and construction phases of projects such as those described above demonstrate the need for Risk Management systems at the engineering stage, especially when an international component of execution plans includes the use of offshore, subsidiary or low-cost centers for detailed engineering. Contractor Risk Management techniques, even on complex projects, are straightforward and direct, but require constant discipline and a realistic acknowledgement of the realities of the contracting process. Dedication to a Risk Management system with objective criteria is vital in order to make Risk Management results predictable, consistent and to allow contractor management to rely on those results. These systems are most effective when adapted to acknowledge the commercial and transactional realities of the contractor in the cycle of developing, bidding and executing engineering and construction projects. Effective Risk Management at the engineering stage can prevent development of dispute situations and enhance project success while increasing the bottom line for both owners and contractors.