# Planning, Procurement, Partnering

Revolutionary Ideas for Successful Coordination of R/O Projects


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## Introduction

Concurrent with the extraordinary growth of the reverse osmosis industry, there has been a distinct change in the procedures employed for designing, contracting, constructing, and commissioning reverse osmosis plants. This paper will briefly review the growth statistics for the industry and report on trends in organization and procurement. Going back to the basics, the goals for each member of the project team – owner, engineer, general contractor, and system supplier – will be reviewed and evaluated as to whether or not the goals are being achieved by current procurement methods. Ideas will be presented on each party's role from design and procurement through construction, commissioning, and operation.

The primary methods for construction contract organization will be compared and contrasted. They will include the following:

- Parallel Prime Contractors
- Single Prime Contractor
- Single Prime Contractor with Assigned, Separately Bid, ROEM Subcontractor
- Strategic Partnerships (Design/Build, Negotiate/Build Contracts)

The potential advantages and disadvantages of each will be discussed.

Additional topics will be addressed including questions of unit responsibility, depending on the type of contract chosen. Observations and ideas will be presented on formulating bid documents and contracts to ensure accurate, fair bids and smooth construction projects and to minimize conflicts, delays and overruns. The frequency and potential causes for re-bidding of major projects will be addressed. The concept of partnering will be discussed specifically in relation to the reverse osmosis industry.

## Growth of Reverse Osmosis Industry

Although humans have been treating water in some manner for drinking since before Christ, the treatment of drinking water did not become prevalent in Europe and America until the 19$^{th}$ century. Early water treatment processes primarily utilized sand filters. Eventually coagulation and disinfection were incorporated. As the industry grew, governmental regulation followed correspondingly. The Public Health Service Act of 1912 included a section on waterborne diseases. The Environmental Protection Agency was created in 1970, followed shortly thereafter by the passage of the Safe Drinking Water Act (SDWA) in 1974. The purpose of the act was to achieve uniform safety and quality of drinking water in the United States by establishing maximum acceptable levels of identified contaminants [1]. In 1986, Amendments to the SDWA were passed that created stringent requirements for treatment to reduce turbidity and chemically disinfect water. The Amendments also established new regulations on synthetic organic chemicals, lead, and copper in drinking water. The Surface Water Treatment Rule (SWTR) was developed from the SDWA Amendments. It sets forth requirements for treating drinking water for viruses and bacteria. Also promulgated in relation to the SWTR were new regulations on disinfection by-products [2].

The effect of these rapidly burgeoning regulations has been to force the water treatment industry to study and implement non-conventional treatment processes. One of the non-conventional treatment processes that has most successfully met these ever-changing regulations has been desalination technologies, in particular, membrane processes.

In addition to increased regulation, explosive population growth in water-scarce coastal areas has contributed to the popularity of desalination processes. Increasing population in arid regions also advanced the need for desalination technology, in fact, desalination was first implemented on a large scale in the Middle East. Beginning in the 1970's, distillation plants in the Middle East have comprised the majority of the world's desalting capacity. Technological advancements in reverse osmosis membranes enabled R/O to gradually become more popular. Currently, it is estimated that membrane processes constitute approximately 25% of the world's desalination capacity. Distillation still reigns, providing the remaining 75% of the world's desalination [2].

Desalination processes have grown tremendously from initiation a mere 30 years ago to the influential industry it is now. This explosive growth is expected to continue as fresh, clean water supplies continue to shrink and environmental regulations continue to grow. It has been projected that 1 in 3 people worldwide will be living in countries with inadequate freshwater supplies by the year 2025 [3]. Desalination can help meet the world's water needs by successfully treating seawater, brackish groundwater, and in some cases, polluted surface or groundwater, and even wastewater.

It is apparent the technology is here to stay. Owners and engineers find themselves turning to this technology more and more often. Issues related to the development, design and procurement of a project incorporating this technology is the subject of the paper. A large portion of this paper presents discussion that would be appropriate to any construction project, however, there are several aspects of desalination projects that make this topic particularly relevant.

## **<u>Owner, Engineer, General Contractor, and Specialty Contractor – Responsibilities and Goals</u>**

In conventional construction projects there are three main parties: the owner, the engineer, and the contractor. In specialized process projects, a specialized system supplier with particular expertise on the process is also usually involved. This party is also called an original equipment manufacturer (OEM). Each of these parties are a necessary and valuable member of the team. The key to obtaining a successful project is organizing the project so that all project participants achieve their individual goals, while minimizing adversarial relationships. The goals for each project member are generally described below:

***<u>Goals</u>***

- <u>Owner</u> – obtain a quality project, within budget, on schedule, with minimum hassles, a smooth transition into ownership, and efficient and easy operation.
- <u>Engineer</u> – protect the public health, facilitate the Owner's wishes, be associated with a quality project, and make money.
- <u>Contractor</u>– execute work to create a quality project, successfully interpret the Owner's and Engineer's intentions, and make money.
- <u>OEM</u> – utilize experience to build a quality system, successfully implement the Owner's and Engineer's intentions, and make money.

The responsibilities for each project member can briefly be described as follows:

***<u>Responsibilities</u>***

- <u>Owner</u> – have a definite concept of the scope of the project to minimize changes, provide for payment in a fair and timely manner, and mediate disagreements between Engineer and Contractor.
- <u>Engineer</u> – interpret and implement Owner's directions, evaluate bids for recommendation of responsible bidder, administer contract fairly and efficiently, provide technical guidance to Contractor promptly to minimize delays.

- Contractor – construct quality project using best standards of practice in the industry, deal with necessary and reasonable changes to the work fairly, select a qualified OEM, if OEM is an assigned subcontractor.
- OEM – utilize specialized experience to construct quality system, develop detailed process design and fabrication plan based on construction documents, recommend enhancements to the work for consideration, deal with necessary and reasonable changes to the work fairly.

These descriptions, though brief and concise, summarize the basic goals and responsibilities of the construction project members. All of the members share the over-all goal of achieving a successful and trouble-free completed project. It does not seem like meeting these responsibilities and achieving these goals should be so difficult. Unfortunately, more and more often, that is not the case. The statistics depicting the proliferation of construction disputes are astonishing. It is reported that 67% of all construction organizations were involved in significant project disputes in the last two years. In 1994 the American Arbitration Association resolved 3564 construction claims with an original disputed value of $780 million at a cost of $150 million. The worst indicator of all is the number of lawyers specializing in construction law has increased from about 500 in 1981 to over 5500 now [4]. These disputes cost all parties involved. Failure to deal promptly with changes or questions costs 10% to 30% lost time per day. The expense to owners and engineers is significant, though difficult to calculate. The expense to contractors is readily measurable. The reported pre-tax profit for the construction industry averages 2.5%. The reasons most often cited for construction difficulties are as follows [4]:

1. Contractors who bid too low
2. Ambiguous contract documents
3. Owner discretionary changes
4. Unrealistic risk taking
5. Failure to deal promptly with changes
6. Poor communication

The latest trend in the effort to reverse these appalling statistics is called Partnering. Partnering is a thought process wherein the parties of the construction project are encouraged to think of each other as members of the same team, rather than adversaries. The process and advantages of partnering will be discussed in more detail later in this paper. Before partnering can really be effective, it is advantageous to set a project up in a manner that will minimize conflict and enhance cooperation and ensure the project is successful. Partnering efforts may be a lost cause if adversarial relations have already developed due to conflicts, misunderstandings or feelings of unfair treatment during bidding.

## Contract Organization

When the reverse osmosis industry was in its infancy, there were no specialists in designing or constructing facilities. The membrane manufacturers developed the membranes and, in conjunction, in-house expertise was necessarily developed to design systems incorporating the membranes. The same was basically true for distillation processes.

Commonly, an engineer would be selected to design a facility to the point of laying out the site, structure and ancillary equipment, with assistance from the membrane manufacturer. The actual membrane process would likely be shown only as a "black box". A general contractor would be contracted to build the facility, with representatives from the membrane manufacturer or some other specialist usually designing and building the membrane process equipment. Unfortunately for the owner, the membrane manufacturer may not have been involved in service after the completion of the project to the extent the owner may have desired. The process was new and the equipment did not always work as intended. Service and maintenance often fell to the contractor that built the plant. From the experience gained by this hands-on training, a few contractors became knowledgeable on the technology. Also, as the industry grew and projects became more numerous, more OEM's (and engineers) became specialists in the field.

At that point in the evolution of the industry, it was customary to select an engineer or sub-consultant with some level of experience in designing membrane facilities – although the fine points of the process were still not typically detailed. The process requirements could almost be defined as a performance specification. The treatment system would be negotiated with a qualified OEM or competitively bid with only qualified companies being allowed to bid – qualified companies being either membrane manufacturers with construction capability or specialty contractors with specific process experience (OEM's). A general contractor would normally be selected separately for the site work and building, but the process-related equipment would be supplied by the OEM, usually directly contracted to the owner. This provided the owner the assurance of accountability and unit responsibility for the operation of the process.

It was in this manner that hundreds of facilities were successfully and cost-effectively designed, bid, built and commissioned in the 70's, 80's, and early 90's. Most of those facilities are still operating successfully today.

A combination of evolving factors caused this process to gradually change. In an effort to streamline the bidding and construction process, it seemed desirable to combine all aspects of a project into one contract. For some owners, this may be beneficial. As more engineers gained experience in this increasingly popular technology, designs became more and more detailed. Projects would be bid to general contractors with little or no guidance or requirements for a qualified OEM to be involved. As a result, general contractors with no knowledge of the intricacies of the process would be selecting an OEM based primarily on low price (possibly made even lower through the unethical practice of bid shopping), with little weight given to experience or capability. Also, more and more OEM's entered the market, each more willing than the last to contractually submit to conditions that more experienced OEM's knew were ill-advised and detrimental to the success of the project and the industry as a whole.

A recent review of major membrane construction projects would seem to indicate this evolution in procurement procedures has had a negative impact on the industry. The percentage of projects that experience significant problems has increased exponentially. One or more of the following problems commonly plague projects, at great expense to the owner, engineer and contractor: the bids come in over budget, the project has to be re-bid due to irregularities or disputes, the project concludes with some level of arbitration or litigation required at the end to settle disputes, process enhancements are not incorporated because there is little or no communication, or – most unpleasantly for the owner – he is left with a project that is less than satisfactory and he has does not have unit responsibility for reparations.

In every industry, change is inevitable. The purpose of this discussion is to try to find ways to take the positive attributes of this evolution and improve on them and eliminate or at least minimize the negative aspects. The types of contracts described below will be evaluated for their application to membrane projects.

***Parallel Prime Contractors***

This method of contracting involves dividing the project into two (or more) separate contracts. Typically the site work, building, general electrical and possibly other ancillary work such as raw water supply or finished water storage tanks are combined in one contract. This contract would be bid to general contractors with mechanical and general utility work experience. The main process work including the desalination process equipment, structures, chemical systems, and instrumentation and controls, would be bid to specialized OEM's. Each contract is bid separately, each contract is administered by the construction engineer, and each contractor is directly accountable to the owner. The advantages of this method are as follows:

- By pre-qualifying the OEM's invited to bid on the process contract and having direct control over the bid evaluation, the owner and engineer have greater assurance of having a quality system built, with minimum hassles.
- There is freer communication and open exchange of ideas and improvements between the OEM, engineer and owner for project enhancements.
- Each contractor is directly accountable to the owner which provides the owner more control in quality, payment and warrantee issues. For example, to obtain service, additional assistance or repair on key process work, the owner does not have to go through a less knowledgeable and potentially less motivated third party to get satisfaction.

- The party bidding each portion of the work is experienced in their fields, and the bids are more likely to be responsible, ensuring a more successful project with less chance of change orders or cost-overruns.
- May save money by preventing the OEM's substantial contract value from being marked-up by the general contractor.

The potential disadvantages to this method are:

- Bidding and administering two contracts can be more cumbersome than having all work supplied under one contract.
- Diligent effort must be made to maintain coordination and communication between both contractors for smooth implementation of the project.
- As each contractor is not accountable for a portion of the project, without careful description and division of responsibility, problems with "finger-pointing" could arise.

This was the method more commonly used in the early and middle years of the development of the reverse osmosis industry. It has recently, and unfortunately, in the opinion of some people, become less popular lately. This method is generally very successful as long as the division of work is clearly described in the contract documents and carefully maintained throughout the project.

### ***Single Prime Contractor***

This method has been prevalent in the construction of large municipal projects over the past several years. The entire project is set forth in one set of bid documents and one contract is advertised for bid to general mechanical contractors. This method has been used successfully, especially if good contractors and qualified OEM's are pre-selected and listed, required to named in the bid, and their scope of work is carefully described and firmly assigned to be their responsibility throughout the term of the project and warrantee period. Some advantages of this method are stated below:

- Bidding and contract administration are simplified by the use of only one contract.

- The general contractor is ultimately responsible to the owner for all aspects of the work.

Potential disadvantages are:

- The system may be supplied by inexperienced or unqualified OEM's or with no OEM involvement at all, potentially degrading the quality of the plant and the service to the owner, if process scope is not well-defined, or qualified OEM's required.
- Process enhancements are less likely to be proffered to the engineer and owner as the general contractor has little incentive to complicate the project or increase his work load, particularly since he is usually contractually limited to a low margin on extras.

### ***Single Prime Contractor with Assigned, Separately Bid or Negotiated, ROEM Subcontractor***

This method has the potential of combining both the advantages of the parallel prime contract and the single prime contract. The owner and engineer either separately bid or negotiate to a select a system OEM. That OEM is then assigned to the general contractor as a pre-selected subcontractor. The owner and engineer only have to administer one contract. The advantages are:

- The owner and engineer are assured of having a qualified OEM providing the system.
- Only one contract has to be administered.
- The owner has accountability from the general contractor for the entire project (although the general contractor may be able to claim some remission as the OEM was assigned, not selected by him).

Disadvantages may include the following:

- Communication may still be hindered as it would officially have to go through the general contractor, though there is generally more leeway afforded to the pre-selected OEM.
- Since the owner and engineer assigned the OEM to the general contractor, there could potentially exist the same "finger-pointing" problems mentioned in the section on parallel prime contractors.

***Strategic Partnerships (Design/Build, Negotiate/Build Contracts)***

Finally, a method that has become more popular in other areas of construction is being applied to desalination projects. The design/build approach encourages innovations by involving the contractor/OEM in the early phases of the project. They can make recommendations while the design is still being drafted. This minimizes the hassle and expense of change orders once construction has commenced. The advantages are numerous:

- Often the contractor/OEM knows from real-world experience how to save significant time and money on a project and improve its quality and performance.
- The longer involvement of all parties encourages team partnership and eliminates the adversarial relationships for the benefit if the project.
- The selection process usually consists of evaluating three or four pre-selected, qualified teams, rather than sorting through numerous companies of unknown quality.

Currently the main detractor from this method is its novelty and the owners', engineers', and contractors' lack of experience with it. The means do not currently exist for most municipalities to construct projects through this method. As it becomes more popular with industrial and overseas projects, hopefully it will also become more prevalent in the municipal arena.

**Partnering**

Although the term "partnering" is relatively new, the concept is actually old-fashioned. The theory behind partnering is simple: treat each other fairly, with respect, and talk to each other, dispel the adversarial "us versus them" mindset and create a shared vision of the project. The partnering process usually involves bringing in a professional facilitator at the commencement of construction and possibly several times during the project to conduct team-building activities and develop a mutual mission statement for the project. Typically, specific goals are developed for concerns like scheduling issues, jobsite safety, and dispute resolution. Partnering must be owner-driven and have the complete support of the top management of all parties [6].

The benefits of partnering are evident, if the process is implemented successfully and all parties are committed to maintaining the goals throughout the project. The benefits include: projects are completed on time and within budget, problems are solved pro-actively by individuals working together, all parties feel good about having created a successful project, there are no residual disagreements or litigation claims after project completion [7]. Partnering has had great success and holds great promise for the future.

## Additional Topics

### *Relationships*

Partnering is basically about building good relationships within the construction project team. As in any relationship, a collective understanding of each party's role lays the groundwork for preventing misunderstandings and developing mutual respect. In construction projects, this understanding can only be ensured by all parties knowing their role in the project. The owner must be knowledgeable of the desired function of the finished facility, the construction requirements of the project, and the realistic budget and time needed to complete the project. The engineer must understand the owner's needs and translate them into clear, accurate construction documents. If the project involves special work, as in a desalination facility, the engineer should be careful to see that the specifications are practical and that they can be met without excessive cost, time delay, or trouble. Unless the engineer is an expert in the specialized field, it is advisable to make provisions for having a competent sub-consultant review the documents before they are finalized and retain their services throughout the project for shop drawing review and periodic consultation [8]. The contractor, and/or a specialized OEM, bears the obligation of preparing a responsible bid, pointing out conflicts or deficiencies, preferably prior to the bid, if time allows, and constructing the project utilizing the best standards of the industry. The contractor/OEM team is also responsible for dealing with changes fairly, and seeing the project through completion, start-up, training, and remaining accessible throughout the warrantee period and beyond.

### ***OEM's, Bidding and Construction Periods***

The definition of the contractor's role points to the value of including an experienced OEM in the desalination project. Preparing a responsible bid and executing a successful project requires detailed knowledge of the intricacies of the process. Noticing conflicts or deficiencies or being able to recommend improvements prior to a bid saves money and time for all parties. Changes to the work are far more cumbersome after the project is under contract. This also shows the significance of being provided sufficient time to prepare bids. A relatively long time is required to organize project, financing, design, obtain permits, and prepare construction documents. Frequently bidders are allowed a short time to prepare bids. This often results in bid inadequacies and costly mistakes. Bids are expensive to prepare, and the contractor is fraught with fears of being too low, getting the job and then losing money; or being too conservative and coming in too high to be competitive. Unfortunately, the low bid methodology of selecting contractors may present difficulties, if contractors and OEM's are not pre-qualified, due to the likelihood of the contractor attempting to recover costs through excessive changes orders and extras. A realistic bid period involving pre-qualified contractors and OEM's more than often results in a smoother construction process and an better finished product. Likewise, allowing for adequate construction periods will provide smoother construction and a better finished product. Insufficient construction schedules can lead to undesirable improvisation, inadequate time for thorough detailed design and mistakes due to stress. One idea for assessing required bid and construction periods would be to poll several experienced OEM's and use an average of the times they requested [9].

Related to the topic of relationships is the issue of trust. Trust is key to all good relationships. Trust is developed over a period of time through open communication and risk taking for the sake of the team and the over-all success of the project. Parties who are aware that their relationship will be of a short duration are more likely to resist agreement, less likely to communicate freely, or take risks for the benefit of the project. On the other hand, if the parties have had and hope to continue having a long term relationship, cooperation, risk-taking, and honest communication is more likely. The parties may fear that the tables may be turned in the future and they will be endangering future work opportunities. This concept of trust is not only project-specific, it applies to the desalination industry as a whole. The owner and engineer will feel more at ease knowing the company responsible for providing their expensive facility is a company that has been involved in the industry for a significant number of years, that has a face or faces they have seen at meetings or conferences numerous times, and will continue to be around to provide service for years to come [10]. On a few recent projects, detailed construction documents have been prepared to the point that the engineer and owner have determined an OEM is not necessary, the thought being, apparently, that the owner will experience over-all project savings by having the complete work constructed by a general contractor under a lower margin than an OEM might command. Obtaining a satisfactory outcome under this arrangement would require intensive oversight and involvement of the engineer and owner throughout the project. The owner is liable to have minimal support after construction completion and during the life of the plant. It is doubtful that much, if any cost savings would be realized, as a general contractor with no desalination experience will be inefficient at detailed fabrication and installation requirements and will not have the long-term relationships with the network of specialty suppliers an experienced OEM will have. Additionally, an experienced OEM will have a knowledgeable technical staff involved during the project, enabling the owner and engineer to utilize the resources of their experience for the benefit of the project.

## ***Contractor and OEM Pre-Qualification***

Several times throughout this paper OEM pre-qualification has been mentioned. Pre-qualification procedures can be very involved or they can be brief and concise. A complex pre-qualification procedure could involve lengthy technical submittals and interviews with the OEM either at the OEM's facility or at the owner's office. At a minimum, a pre-qualification survey should be performed requesting the following information [11]:

- description of company, background, and years of experience in desalination field
- list of installations, including name and address of owner
- any other references the OEM may want to submit
- project descriptions and photographs of installations similar to the project being considered
- resumes for key project personnel
- description of company's manufacturing facilities, fabrication processes, quality control and testing procedures and installation practices and field services capabilities
- information on major subcontractors the OEM would use

Similarly, the owner may want to pre-qualify the general mechanical contractors to ensure they are reputable, they do not practice bid-shopping, and not prone to excessive change-orders.

***Owner-Furnished Materials***

Occasionally, the owner may decide there is an advantage to obtain some project materials directly, rather than through the contractor or OEM. The reasoning is usually based on the expectation the owner will save money by eliminating sales tax or avoiding contractor mark-up. It is possible in some areas the sales tax exemption may be passed on to the contractor because he is performing work for the tax-exempt municipality. In some cases the savings to the owner may be significant. In other cases the savings may be negligible, particularly if any potential savings are consumed by the occurrence of subsequent problems. In membrane facilities, the most common item removed from the OEM's scope and provided by the Owner is the membrane elements. The owner may want to consider the following issues in deciding whether or not to direct-purchase membranes. The same general consideration would apply to other materials such as feed pumps or cartridge filters.

- The membrane elements are the key component to the successful performance of the plant. Proper selection, review and coordination of membrane system design and element test data is critical. The performance of the elements can vary significantly between manufacturers. Although the project engineer will be coordinating these tasks and is be capable of performing them, the engineer is responsible for the oversight of the entire project, which is usually quite complex. It is invaluable to the owner to have another agent, experienced full-time with membrane system design and construction responsible for coordinating with the membrane manufacturer. The OEM cannot be responsible for system performance if he is not performing the duties described above.

- Additionally, if there is a problem with the performance of the elements, the owner is less capable to provide the time, expertise or manpower to evaluate or follow-through with the manufacturer to resolve the problem.
- Also, there is the consideration of membrane warrantee. Normally, the OEM supplies and installs the membranes. Correct installation requires skilled, experienced staff to handle the membranes properly so as not to contaminate the system, to ensure all seals are sound, o-rings seals are not compromised, the vessels are shimmed for proper fit, etc. If the OEM does not supply and install the elements, he cannot be responsible the performance. The owner then has no single entity responsible for providing a functional process and “finger-pointing” is liable to ensue.
- Finally, it should be noted the level of effort required in purchasing the membrane elements may be significant. A few of the tasks involved include coordinating review of submittals with the Engineer, being responsible for ordering, reviewing individual element test data, scheduling and coordinating delivery, ensuring proper storage, and coordinating installation, start-up, and training with owner’s staff, engineer, related subcontractors and membrane manufacturer’s representative.

In conclusion, there are many issues to consider in evaluating the supply of membranes. It is likely the cost savings may not be significant, as skid suppliers may be able to obtain the membranes for a slightly lower cost since they are generally large volume purchasers of membranes. The owner may wish to contact other municipalities regarding their experiences with membrane purchasing arrangements.

## Conclusions

In conclusion, it is evident the future for desalination technology is bright. It seems almost daily a new report is publicized regarding water supply problems, health concerns or additional water quality regulations. All members of this industry serve to benefit from improving the cost-effective, smooth implementation of high quality projects. The problems of expensive and time-consuming re-bids, significant over-runs and disputes, poor quality construction, and basic technical problems contribute to the perception that desalination technology is expensive and complicated. It falls to all members of the industry to consider their role in working to rectify the problems and help the industry achieve its full potential.

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