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Modularization: The key to success in today's market

The world economic order is rapidly changing. A transition is underway, led by the sudden collapse of crude oil and natural gas prices. Major corporations are being restructured, and major capital projects are being reevaluated in a market where supply, demand and pricing have suddenly become uncertain. In addition, developing countries are quickly building new plants and infrastructure to support a rapidly growing middle class that demands all the benefits of modern industrial production.

At the same time, hydrocarbon feedstock is being discovered in increasingly remote geographies. In such places, infrastructure is usually lacking and the climate can be extreme. These issues are exacerbated by a construction labor market that has also become unpredictable. In some places, an abundance of construction labor exists. Unfortunately, this is usually not where the projects are being developed.

In this environment, only the most financially sound projects will be able to move forward. Today, successful projects tend to be smaller, with stringent cost parameters and extremely tight project schedules. To meet project quality, schedule, cost and risk, it is essential to establish the optimum project execution strategy.

Here, the pros and cons of modularization vs. field construction are outlined. By fabricating key components in a controlled environment, it is possible to minimize risk, improve quality and stabilize field construction costs, which are typically high and variable. Modularization also facilitates plant startup because piecemeal checkouts can be made in a controlled environment.

Modularization strategy.

Modularization or prefabrication requires significant planning before moving forward. Many facets must be considered to make project execution effective. Sufficient time must be allocated to assess the various options, and to bring all the elements of modularization together.

The authors have experience on major projects in which not enough time was allocated to evaluate modularization options, and the concept had to be abandoned because the schedule became critical. Ironically, modularization (which is usually associated with shorter schedules) was not considered a viable option in this instance because there was not enough time to evaluate all options. Modularization can certainly shorten time in the field, but awareness must exist of all upfront planning and options to be considered.

Drivers for modularization. Modularization may be considered for many reasons, including:

- Limited availability of skilled and affordable labor
- Remote site access and severe site weather constraints
- Desire to minimize field time and reduce construction costs
- Reduction of site waste
- Improvement in quality due to controlled environment
- Extensive factory acceptance testing (FAT) required
- Repeatable construction that lends itself to duplication
- Equipment replacement at an operating plant where downtime is not possible.

A cold weather environment may pose a problem for obtaining skilled and affordable construction labor. The more reasons that support modularization, the more convincing the argument for management to agree with this approach will be.

On the other hand, some projects do not lend themselves to modularization. For example, if reasonably skilled and affordable construction labor is available and the site construction is considered routine, then the right decision may be to not consider modularization. All factors must be considered in deciding whether to pursue modularization. Some factors, such as cost and schedule, can be quantified. Others, such as risk and quality, must be assessed in qualitative terms based on experience.

Types and sizes of modules considered. Since a huge tradeoff exists between module size and shipping costs, considerable thought must be given to module size and configuration. If downtime at an operating facility cannot be tolerated, then the right decision may be to use the largest shippable module possible.

In the authors' experience, an entire modularized ethylene furnace was shipped to minimize downtime in an operating plant in which an existing furnace was being replaced. More typically, however, the tradeoff between shipping and site assembly costs comes to bear in configuring the modules. Also, access to waterways and rails becomes a huge factor in determining module sizes. Road restrictions limit size-based jurisdiction restrictions, so alternate shipping means are important. Some typical module types include:

- Mega-modules (over 500 t; require special shipping)
- Large and intermediate modules (require barge or rail)
- Truckable modules
- Pipe rack modules
- Skid-mounted equipment modules
- Hybrid modules (partially completed in the shop and fully assembled in the field).

On any given project, there will likely be multiple types of modules based on the project's unique features. Some examples of skids fabricated in the US and the Middle East are presented in FIGS. 1 and 2. FIG. 1 depicts a flue gas conditioning module that is part of a large process plant. This module was fully fabricated in a local shop in the Middle East to achieve the desired schedule. FIG. 2 shows a railcar loading skid complete with strainers, flowmeters, pressure regulators and prover connections for use in bulk liquid terminal operations.

Contracting strategy for module fabrication. Several questions must be answered on this topic. For example, is it best to build the modules in a low-cost country, knowing that this could increase shipping costs? Should multiple module fabricators be considered in light of workload and schedule, and could this pose interface problems if the work is not closely coordinated? Should the module builder be given the scope of buying all material so that material delay does not become a factor for the module builder, which could increase costs? If schedule is critical, it may be wise to keep as much scope with the module builder so that no hindrances to performance emerge, since this strategy has a cost premium.

It is particularly important to conduct proper due diligence of the module fabricators being considered. For the most part, the success of the project will rest largely on the performance of the module fabricator. In considering a large international job, this could involve the evaluation of 30–50 fabricators. Even on a smaller project requiring modularization, 20 or more interested bidders could easily emerge. Examining each company's past performance is a key indicator of their capabilities. Also, it is important to see how much work they are capable of performing, and how much work must be subcontracted. Reducing interfaces is key to ensuring project success.

As is often the case, many of the decisions regarding modular fabrication will be a tradeoff between schedule and cost. Considering that the modules are a key driver in the overall project, the authors' perspective is that less interference with the module fabricator's work will make for a better project. Of course, continual performance monitoring is critical to ensure that all facets of the modularization remain on track.

Engineering scope and planning. The interface between the owner; the engineering, procurement and construction (EPC) contractor; and the module builder is crucial. Thought must be given to how engineering will be addressed. Experience shows that piping and instrumentation diagram (P&ID) finalization often lags; therefore, steps must be taken to move this part of the process expeditiously. A late hazardous operations (HAZOP) assessment can have a drastic effect on design; for this reason, such reviews must be timely.

FIG. 1. Flue gas conditioning module. Photo courtesy of Descon Engineering.

Since 3D models are the norm, a plan must be established for how the design will be coordinated. A joint team between the engineering organization and module fabricator is an option. The module fabricator often has the best ideas regarding module design details, so their involvement is crucial. If the owner has basic data for the process or skid, one possibility is to partner with a fabricator with design experience and capabilities with modules.

With this approach, the fabricator completes the production design based on final P&IDs and specifications. Utilizing the latest plant design suites, all of the steel, equipment, piping, electrical and instrumentation, etc., are designed and integrated in a common platform. With collision checking, walkthrough capabilities and automatic drawing generation, the benefits include reduced engineering and design hours, along with quality deliverables released for construction.

Another possibility is that tie-in points are provided to the module fabricator, and the design team provides the detailed module design within guidelines of the overall engineer. The worst-case situation is where the engineer hands a set of drawings to the module fabricator without significant involvement from the fabricator.

Input from the construction and operations crews is crucial during engineering. An unacceptable outcome of module fabrication is a module that is not constructible in the field, or does not satisfy operational requirements. Also, the possibility of saving project costs exists by considering some form of hybrid models during the course of design. For example, the original plans may call for a huge vessel to be included in the module. It may be prudent to have this vessel delivered separately to the field due to size/weight considerations, or because it may be completed late in the overall project schedule. Flexibility in design approach should be the watchword in module design, since the best ideas will surface throughout the design process.

Coordination of material and equipment. One reason that modularization is seeing a renaissance is because tools exist to facilitate the coordination and integration of components. Known as building information modeling (BIM), the software enables the proper tracking of materials. It is crucial that material is ordered on time, and that components are delivered to the right place (either the module shop or the field) according to the project schedule. Documentation is also crucial, so all paperwork must follow material.

Coordinating material can be particularly challenging if some material is free-issued to the module fabricator, and if the fabricator is also counted on to provide material. On a single drawing, there could be material/components being sent in various directions: owner/EPC to fabricator; owner to the field; and fabricator buying and sending connecting hardware to the field. Drawings must be clearly marked and managed to ensure that all components are delivered to the proper location as per the schedule.

Cautions.

The idea of utilizing modules on a given project is the result of one or more of the aforementioned drivers. In every case, the decision is being made to overcome some perceived obstacle on the project. The module fabrication (and implementation) itself can turn into a nightmare if proper precautions are not taken. Aspects to consider include:

- **Ensure the overall schedule scope is big enough.** While the modules themselves will reduce field time, care must be taken that enough overall schedule time is allotted for proper planning.
- **Confirm that the design is well-coordinated and timely.** As previously noted, all of the key parties involved will want to submit input to the design. The authors have been involved in projects where so much input is being considered that engineering never ends. This will kill the schedule.
- **Do not tie the hands of the module fabricator.** Owners and EPCs are often eager to be involved in every detail of the module fabricator's work. The authors advise readers to let the experts do what they do best. Being too prescriptive will tie the fabricator's hands and create schedule problems. If the module fabricator buys as much material as possible, this may also reduce interfaces.
- **Get the right modules to the field at the right time.** This sounds like straightforward advice, but there have been numerous occasions where construction was halted because the pieces are provided in the wrong order.
- **Preassemble side-by-side modules at the fabricator.** The best way to ensure things work together smoothly in the field is to preassemble modules at the fabrication facility. This permits tie-in problems to be resolved before they arise in the field.

Pros and cons of modularization. Various obstacles can impede the widespread use of this technique, but likely pros with modularization include:

FIG. 2. Railcar loading skid with strainers, flowmeters, pressure regulators and prover connections for use in bulk liquid terminal operations. Photo courtesy of ShureLine Construction.

- Less labor in the field, particularly where construction labor is limited
- Controlled conditions for construction improve quality and reduce waste
- Fewer jobsite environmental impacts
- Reduced requirements for onsite materials storage
- Increased worker safety through lower exposure to field hazards
- Improved schedule by parallel execution of construction tasks
- Permitting and civil work can proceed in parallel with shop fabrication.

Likely cons with the modularization technique include:

- Considerable upfront planning needed to avoid engineering delays
- Coordination of engineering activities becomes complex with multiple parties
- Material control can become more cumbersome
- Shipping costs and challenges rise to a new level.

Recommendations. In today's highly demanding chemical process industry, modularization can enhance project development and execution. By fabricating key components in a controlled shop environment, it is possible to accelerate schedule, minimize risk, improve quality and control uncertain field construction costs. Modularization also facilitates plant startup.

Jobsite environmental and safety performance can be improved, and permitting and civil work can be accelerated. Considerable upfront planning is necessary, and coordination of engineering activities with multiple parties must be carefully managed. HP

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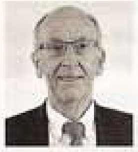

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