



(RESEARCH ARTICLE)



Design aspects, consideration for modularization layout and piping design for optimization of modularization project

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World Journal of Advanced Engineering Technology and Sciences, 2021, 02(01), 011-016

Publication history: Received on 06 December 2020; revised on 14 December 2020; accepted on 16 December 2020

Article DOI: <https://doi.org/10.30574/wjaets.2021.2.1.0036>

Abstract

In chemical, petrochemical and Oil and Gas industry, few decades back Modularization concept was executed for remote site location, extreme climatic conditions but now a days Modularization concept is becoming popular and extensively utilized irrespective to site location and climatic conditions because of its potential to reduce schedule, minimizing cost, effective utilization of skilled labor, for better quality with maximum safe environment, reduction in space requirements for plant layouts and reduction in installation cost.

This paper will discuss Modularization design approaches, Consideration for Modularization layouts, consideration of piping design for optimization of modularization project. During modularization, size, weight and the center of Gravity (COG) of the module play's important role for finalizing layouts and piping with in module, still constructability, Equipment sizing, equipment layout and piping design are critical factors in modularization.

Successful execution of modularization highly depends on the modularization design approach hence the factor stated in paper will help EPC contractors for optimization of construction by eliminating later changes in design which will be further reduction in cost and schedule impact.

In general construction schedule is largely impacted by piping installation and the cost is increased by rework, which reduces certainty on cost and schedule, the piping design and layout consideration stated in this paper will help construction to minimize on schedule and cost, by eliminating the rework done on the field.

Keywords: Modularization; Modularization design concept; Modularization piping design; Modularization piping layout; Optimization of modularization; Design aspect of modularization.

1. Introduction

1.1. Modularization Design Aspects

For effective utilization of modularization execution the following factors play a major role:

1.1.1. Proven process technology

The process technology has to be proven commercially otherwise the design cannot be frozen in the FEED process, as untested or new process has risk of process modification during detail design, commissioning and operation.

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1.1.2. Transportation analysis

Study Transportation access for site location by means of Heavy haul Road or sea to be done. Transportation access plays vital role in determining module type, size and weight. Considerable thought must be given to module size and configuration as it has huge impact on transportation cost. Right decision to be taken for shipment of the large modules, if downtime at operating facility is not tolerated

Some typical module types include:

- Mega-modules (over 500 t; require special shipping)
- Large and intermediate modules (require barge or rail)
- Truckable modules
- Pre Assembled Pipe rack modules (PAR's)
- Pre-assembled Unit Modules (PAU's)
- Skid-mounted equipment modules
- Hybrid modules (partially completed in the shop and fully assembled in the field).

1.1.3. An Experienced Engineering contractor

For modularization project execution, an experienced Engineering contractor experience in order to minimize associated risk during execution which has potential to increase in cost and schedule.

1.1.4. Early Upfront Engineering

More upfront engineering, capital expenditure, cash flow and resource mobilization is required for modularization project. Around 25% of detail engineering needs to be complete by the final investment decision, vs. perhaps 2 to 3 % for a stick-built engineered plant.

1.1.5. Early Selection of key contractor and vendors

For modularization project execution early selection of key vendors and contractors is essential. The selection and involvement of key vendors early in the design is important because of early requirement of Vendor data (particularly with packaged units) to finalize module design.

1.1.6. Construction involvement at early stage

To address module/equipment rigging and field erection issues, facilitates development of equipment arrangement to ensure arrangement supports vendor/supplier layout requirements construction involvement in the development of the plot plan is critical

1.1.7. Client operations personnel involvement

Operational experience persons are required to participate during FEED to validate the design layout. Client operator personnel have to operate plant for 20 to 30 years, hence it is very much important to get them involved.

1.1.8. Client maintenance personal involvement

Maintenance studies are very important during design validation and each activity (e.g. heat exchanger tube bundle removal, catalyst change) must be considered through step by step to ensure the activity can be performed. Because of the compactness of the modules, normal maintenance procedures like using a crane to remove a pump can generally may not feasible. Special davits, crawl beams, local hoists, etc., are often required to enable effective operation.

1.1.9. Material management

The success of a modular fabrication and assembly relies heavily on the project team and their ability to develop a detailed material control plan, successful implementation of the plan, effectively communicate and collaborate. The material planning to support modular project execution is most critical and important than a traditional stick-built project execution. The success factor for material management is scheduling of material POs and getting material available at the module yard at right time of requirement. In addition, a robust material management system that supports bulk purchases with allocation by MWP is very important.

1.1.10. Early Fabricator involvement

The most effective strategy for modularization project execution is to have fabrication and assembly representatives from an approved module yard integrated early into the project team. Fabricability input should be incorporated into designs, in fact in the conceptual stages to eliminate the need for extensive review later in the project which can result in design changes. . The module fabricator involvement is crucial as the module fabricator has the best ideas regarding module design details. If the contractor has basic data for the process or skid and no much experience in the modularization execution, then option of having partnership with experience module fabricator should be considered.

2. Consideration for modularization layout

For modular driven project “Best” layout is one with maximum modularization and for further optimization of the layout of individual module is also equally important. “Modularization drives the layout” not “Layout drives modularization”.

General engineering aspects to be consider for Modularization driven layouts:

- Equipment’s to be located in the modules relative to the process system. This will help to minimize inter-connecting piping and maintain classification of module types like PAU (Pre-Assembled Unit’s) and PAR’s (Pre-assembled Racks). For further optimization in layout, equipment’s of one sub process systems to be clubbed in one single module.
- In order to reduce the overall weight of the module, optimization of size of equipment’s on the module are governing factor and Equipment’s on the module to laid strategically considering Center of gravity of module, process requirements, maintenance and operational requirements, access and egress way etc.
- Selection of proper type of equipment **is** also matters for modularization driven layout, for examples.

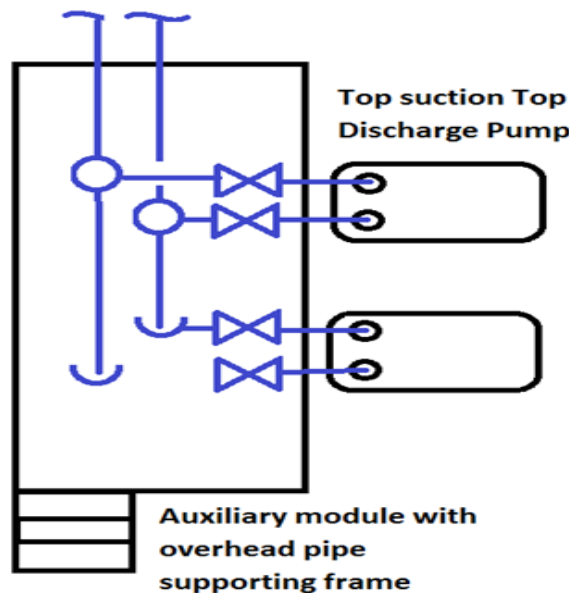


Figure 1 Auxiliary module for Pump piping with Stick built Pump

1. Generally Pumps are to be located outside of the module. Exception is for equipment skids with small pumps placed in the module (i.e., metering skid, deluge skid). Use of top entry and top discharge pump will allow all piping design on one small auxiliary module and pump on the foundation; hence minimization of stick-built piping can be achieved.
2. Optimization of Air cooler can be done by selecting proper type of air cooler like forced draft or induced draft air cooler and also by routing associated piping in the shortest feasible routing.
3. Proper selection of Heat Exchangers for Modularization like Plate and Frame, Spiral, Compa Bloc, Hairpin and shell & Tube/ Kettle Type Re-boiler, will help to optimize size and weight of module.

- Large and or heavy fixed equipment on module to be placed at lower elevation level in order to maintain a low center of gravity for transportation purposes with consideration of process elevation requirements of that equipment. Hence Special attention must be made when locating large and heavy equipment on upper module levels.
- Vertical stacking of equipment in lieu of horizontal spread may be considered for smaller equipment types. This approach allows the module to be built as a unit which helps in pre-commissioning at the fabrication yard prior to shipping.
- In order to facilitate transportation and lifting of module proper provision of structural steel like stub legs with bolted connection and lifting luges to be provided.
- Detail evolution for Shifting of stick built equipment to module to be carried out to justify the modular approach in terms of design, project cost and schedule.
- As rotating Equipment's like pumps and compressor have to be placed on their own foundation. The rotating equipment has to be designed for stick built, however associated piping can be in prefabricated Auxiliary Modules and skids, which will reduce the stick built piping and stick built piping installation schedule can be optimized.
- Stair case of Pre-Assembled Units (PAU's) are preferably to be located in the module, if not possible in order to facilitate stick built installation, associated structure and stair can have bolted connection.
- In order to reduce height and maintain center of gravity of the Pre-assembled Racks (PAR's), stick built approach can be adopted for lower legs of PAR's
- Piping loops on pipe rack to be designed to fit in to same module, if not possible pre-fabricated assembly can be designed for loops protruding outside of module.
- Underground facilities like fire water, Oily drip water, Amine drain, sewer water system, cable trenches to be designed considering route of transportation of module.
- In place stress analysis, transportation analysis (land and sea transportation) and lifting analysis of module to be carried out. Land transportation analysis covers movement of Self-Propelled Modular Trailers (SPMT), Sea transportation analysis covers structural members of the modules have the structural strength to withstand the voyage at sea or river, lifting analysis covers lifting of module by crane.
- During Study phase, 3 D modeling to be done for major or critical pipes for lines indicated in PFD, to determine the equipment's are located at best location.

3. Considerations in Piping Design for optimization of modularization

Further optimization of piping in modularization will help in reduction of schedule and cost, hence Pipe routing to be planned strategically for further optimization of modularization.

General consideration for Piping Design for modularization project execution:

- Ship loose spools to be minimized as much as possible, to minimize site man hours by reducing individual installation of spool. However Ship loose spool cannot be eliminated in some case like pipes connected to load sensitive equipment, piping running out of envelope of module, interface spools between two modules.
- Use of interface spool should be avoided in order to reduce number of field welds, to minimize re hydro test of pipe, if can't be avoided, use of flanged interface to be studied to complete an independent module.
- Scaffolding and rigging requirement to be considered while finalizing pipe routing and deciding on spooling, Pipe routing to be studied to enhance the use of permanent platform wherever possible to minimize use of scaffoldings to reduce field work.
- Piping that does not interface between PAU's but is still outside the shipping envelope, to be avoided by re-review of stress requirements for loop size, location or orientation, to remain within module limits. For vent lines review 'safe location' with HSE, and reroute to an alternative location, in order to avoid being run vertically above the highest point and outside of shipping envelope
- Where multiple lines exit they can be on a common elevation and can be grouped together, it may be possible to provide a prefabricated frame to support and transport these lines. This will allow the lines to be included in a single crane lift for reinstatement. These frames will need to be designed with piping, stress, structural and construction on a case by case basis. Designers should discuss the use of 'C-shape' spools with construction before implementing, to ensure it is the best solution.
- For piping network of utility lines which are non-critical and nonhazardous, flange joint can be provided at interface with modules to eliminate the requirement of additional field weld joints and re hydro test.

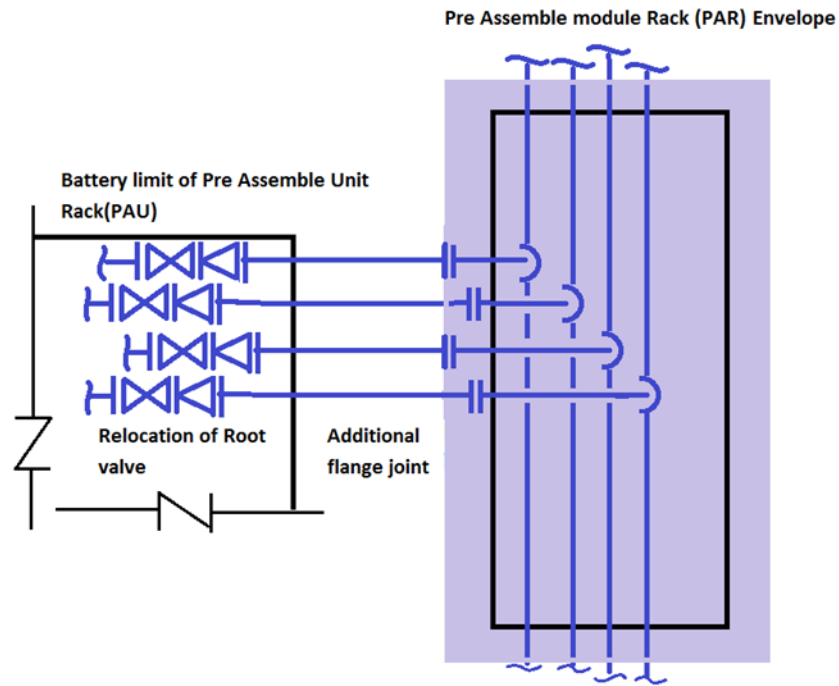


Figure 2 Relocation of root valve from PAR to PAU

- Also root valves at pipe rack can be shifted to module platform for ease of operation and maintenance. This approach of piping design will have each and every module to be independent of each other, so re-hydro test or combine hydro test for these packages are not required field. This will reduce re work done at field and give flexibility for pre commissioning of module at module yard.
- Identify flanged items on the line (spading point, valve etc.) and relocate, where possible, to improve spool shape or size. This will provide a bolted connection in lieu of field weld. Which will make each module more independent hence reduction in rework for hydro-testing or golden weld joint can be eliminated at field.
- For piping interfacing to the adjoining pipe rack, the vertical leg should be located on the rack module, where possible. This will remove the need for vertical shipped loose spools on the module and reduce the number of vertical splices between PAU's.
- Minimize spool size and weight, to improve rigging for spool reinstatement. However in some cases the spool may need to be larger to ensure the cut point is at a more favorable location. Design team should coordinate with construction while studying.
- Consider removal and replacement of the spool. Review the surrounding steelwork design, does the platform support steel need to be modified to improve access, in consultation with construction team.
- Location of break points for pipe running from one module to another module should take into account the supporting of cut ends. Piping stress Engineer shall prefer to use permanent, operating supports, instead of additional transportation supports that will need removing at site. Additionally wherever possible, avoid permanent supports on shipped loose spools.

4. Conclusion

With this paper authors have clarified the design aspects, layout and piping considerations for modular project which are different than traditional stick built project execution.

The layout considerations mentioned in this paper will help minimize construction site activities, maximize utilization of fabrication yard and ease overall construction activates

Piping design considerations for optimization mention this paper which are little different and in addition to stick built piping design considerations are for better interface between modules and between stick built and modules, to minimize on rework like re hydro-testing, and to speed up pre commissioning.

This paper can be utilized, for better engineering of modularized projects from perspective of layout and design approaches, in order optimize cost and schedule in fabrication and construction.

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