ID: 2016-ISFT-291

# A Study on Challenges to Provide Supports for Small Bore Pipelines B/W A Module and Pipe Rack in A Modularised Project

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***Abstract:*** *Modularisation is a revolution in Engineering, Procurement and Construction (EPC) industry. Large and complex projects are being executed in far-reached and insurmountable places very easily by modularisation. This concept makes transportation, construction and fabrication of modules very effective and time& cost saving. Modules are installed on project sites and pipelines are welded or joined by flanges on the site. There are various joints to be fabricated between (i) Modules & Modules, (ii) Module & Pipe rack and also joints within a module. Modularisation is still in its developing phase. There are many challenges in modularisation which are being studied in various projects. Among those challenges, to provide supports for small bore pipelines between a module and pipe rack is always a milestone for piping and Civil, Structural and Architectural (CSA) designers. Usually it is always not possible to keep module and pipe rack very close to each other, because the size of pipe rack is also variable in many modularised project. There is always a scope of variable dimension change of pipe rack during different stages of project. Therefore, it is always a challenge for piping and CSA designers to fix the location of supports and steels in such variable conditions. It is also a major study phase in modularisation to fix the location of all pipelines which connect modules to pipe rack, because of the variability in the location of tiers on different elevations of pipe rack. In ourwork, we have studied various design and fabrication challenges regarding supports of small bore pipelines between modules and pipe rack and suggested some designsolutions under modularised conditions.*

***Keywords:*** *Modularization, Modules, Pipe rack, Pipe Support, Small bore pipe.*

## 1. INTRODUCTION

Modularization is a revolution in EPC industry. Large and complex projects are being executed in far-reached and insurmountable places very easily by modularisation. This concept makes transportation, construction and fabrication of modules very effective and time & cost saving. Modules are installed on project sites and pipelines are welded or joined by flanges on the site. There are various joints to be fabricated between (i) Modules & Modules, (ii) Module & Pipe rack and also joints within a module i.e. (iii) Pre-Assembled-Units (PAU) to PAU. Pipe supports are provided in modules along with pipes, but there are various challenges during fabrication of modules with pipe rack on project site.

### 1.1 PROBLEM STATEMENT

To provide supports for small bore pipelines between a module and pipe rack is always a milestone for piping and CSA designers. Piping designers usually encounter with stress issues in small bore lines and CSA designers provide steels for supports between modules. Supports are provided on a span of 6 m to 7 m for big bore pipelines, but it is required a span of 3 m to 4 m for small bore pipelines because as per stress theory, stress developed in a pipe has an inverse relation with pipe diameter.

### 1.2 OBJECTIVES OF WORK

Two objectives of this work are as follows:

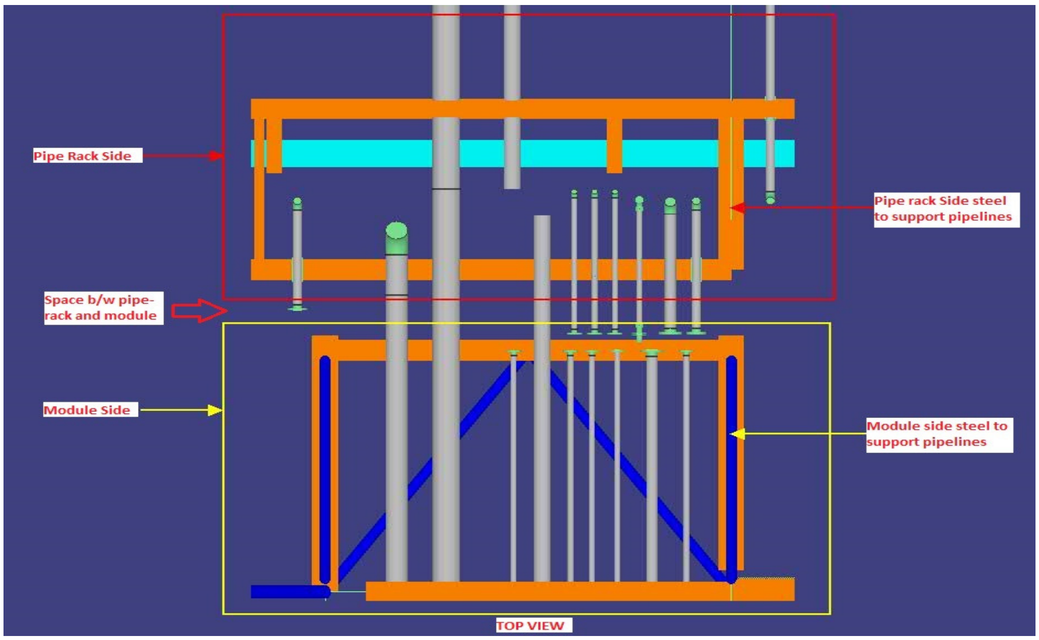
i) To study stress analysis to provide pipe supports for small bore (<=2") and big bore (>2") pipelines between modules and main pipe rack of plant.

ii) To study various challenges faced by piping and CSA design engineers while supporting small bore and big bore pipelines between modules and main pipe rack of plant.

## 2. STRESS ANALYSIS TO PROVIDE SUPPORTS FOR SMALL AND BIG BORE PIPES

Piping layout is analysed by stress engineers for calculation of stress concentration in pipes due to overhanging and locations for supports are decided as per requirements. Though stress developed in a pipe depends on various factors like size, schedule, length and thickness of pipe and temperature of fluid inside the pipe, but three major factors are mainly considered in stress analysis of pipes i.e. (i)

Failure Theories, (ii) Fatigue and (iii) Stress Limits.ASME B31 and Subsections NC and ND (Classes 2 and 3) of Section III of the ASME Boiler and Pressure Subsection NB (Class 1) of ASME Section III are generally used for stress analysis[1].Maximum principal stress theory and the maximum shear stress theory are two most common failure theories which are used to analyse the strength of pipes. Stress limit is generally defined in conjunction with shape factor of pipe. The piping is assumed to be elastic and perfectly plastic with no strain hardening. When a pipe is under a combination of bending and axial tension, the limit load depends on the ratio between bending and tension. Peak stresses are the highest stresses in a local region and the source of fatigue failure. SN curves are used to determine stress limits of pipes.




**F ig. 1. An 3D Model snapshot of Module-Pipe rack interface**

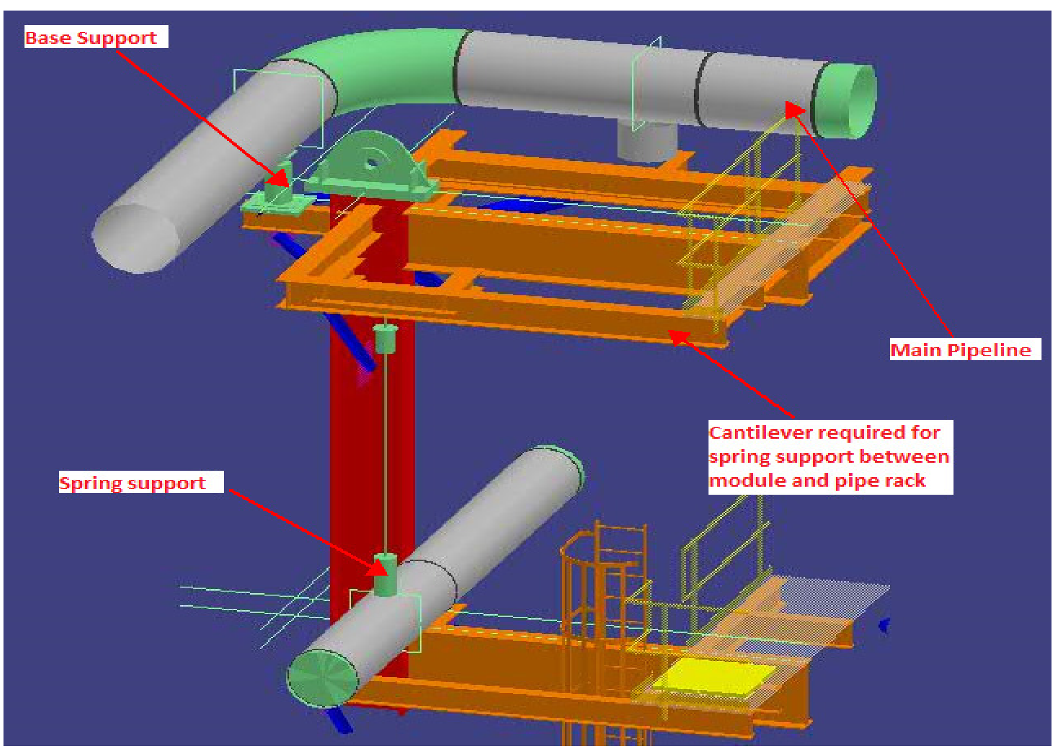



**Fig. 2. Requirement of cantilever and spring supports b/w module and pipe rack**

### 2.1 LOCATION OF SUPPORTS FOR SMALL AND BIG BORE PIPES BETWEEN MODULE AND RACK

Table-1 shows that the requirement of support span for small bore pipes is usually more than the big bore size. Support locations are located taking into consideration of concentrated loads, straight run requirements, loads due to overhanging of pipe, loads on connection. Supports are usually located near any structure as shown in figure-2. There is not any thumb rule or limit to fit the location of each support in piping system inside the module. Small bore pipes are very weak to withstand with a load of valves and other accessories, hence a short span of 2 to 3.50 meter is required for support locations. For big bore lines, the span varies from 3 to 15 meter or more.Let us consider a pipe as a beam, as per Euler–Bernoulli beam theory; stress developed in a beam has an inverse relation with pipe diameter.Hence the difference in span for small and big bore pipes exists because of this inverse relation between stress in pipe and diameter of pipe. [2]

**TABLE 1: Suggested span of support location for pipes**

| Size of pipe (NPS) | Support span range (m) |
|---|---|
| 1 | 2.0 to 3.0 |
| 2 | 3.0 to 3.50 |
| 4 | 3.50 to 4.0 |
| 6 | 4.0 to 5.0 |
| 8 | 6.0 to 7.50 |
| 12 | 7.50 to 9.50 |
| 16 | 8.50 to 11.0 |
| 24 | 10.0 to 13.0 |
| 30 | 13.0 to 15.0 |

### 3. CHALLENGES TO PROVIDE SUPPORTS FOR SMALL BORE AND BIG BORE PIPELINES BETWEEN MODULE AND PIPE RACK

Piping stress analysis is highly interrelated with piping layout and supports design. In initial stages of design execution, stress isometrics of big bore pipelines are extracted by piping layout designers/engineers and submitted to stress analysis discipline. If necessary, layout solutions are iterated until a satisfactory balance between stresses and layout efficiency is achieved. Once the piping layout is finalized, the piping support systems are determined. Stress analysis discipline provides location of supports on isometrics. Piping design completes the requirements of supports provided by stress engineers. Once layout is finalised by piping designers, CSA engineers provide steel for support locations. Figure-3 depicts a typical sequence followed by all three disciplines.

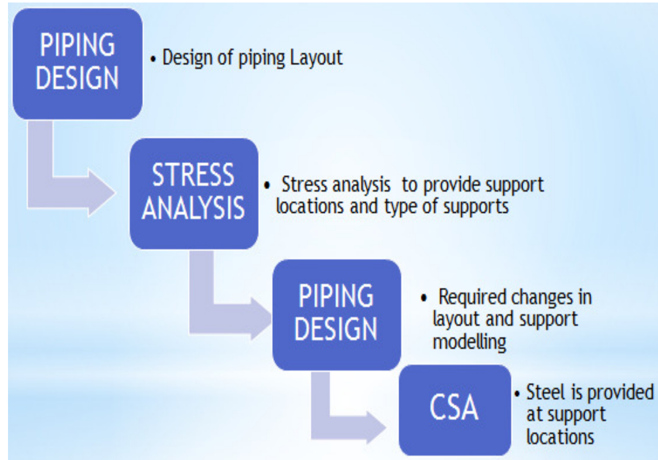



**Fig. 3.A typical sequence of support design**

### 3.1 DESIGN CHALLENGES FOR PIPING DESIGN ENGINEERS

Good pipe support design begins with good piping design and layout. It is a big challenge and aim for piping designers to use the surrounding structure to provide logical points of support, guidance and anchors, so that additional requirement of structure at support locations can be avoided. Generally stress critical points in a pipe are found near heavy valves, PSV and Control Valve arrangements. Designers always aim to routethe pipes in parallel with structural beams in horizontal or vertical direction. A space constraint is always associated in modules and to provide supports in valve assemblies is a big challenge, because a pipeline with heavy valves requires supports at very short span. A pipe spool which is provided logical support must have a minimum length as per type and size of support as shown in figure-4.

Pipe supporting inside the module is not as difficult as outside the module near pipe rack. Because pipe rack and modules are always installed at defined and fixed distance from each other. Usually, big bore lines can be safely connected without any support location required between modules and piperack because support span is greater than the distance between modules and pipe rack. Sometimes, the size factors of pipe rack i.e. height, width, numbers of tiers etc. are considered as variable and there is always a future scope of expansion in dimensions of pipe rack. Thus the length of pipe spools is also variable between module and pipe rack and hence to provide support locations for small bore lines becomes a tough challenge and mile stone for stress and piping design engineers. Many pipelines of different size are routed inside the modules, but these lines are connected to other modules through pipe rack only. These lines are routed with fulfilling various requirements like free draining and utilities etc. Hence, to route all lines by using surrounding structure is not as easy as it is inside the module.

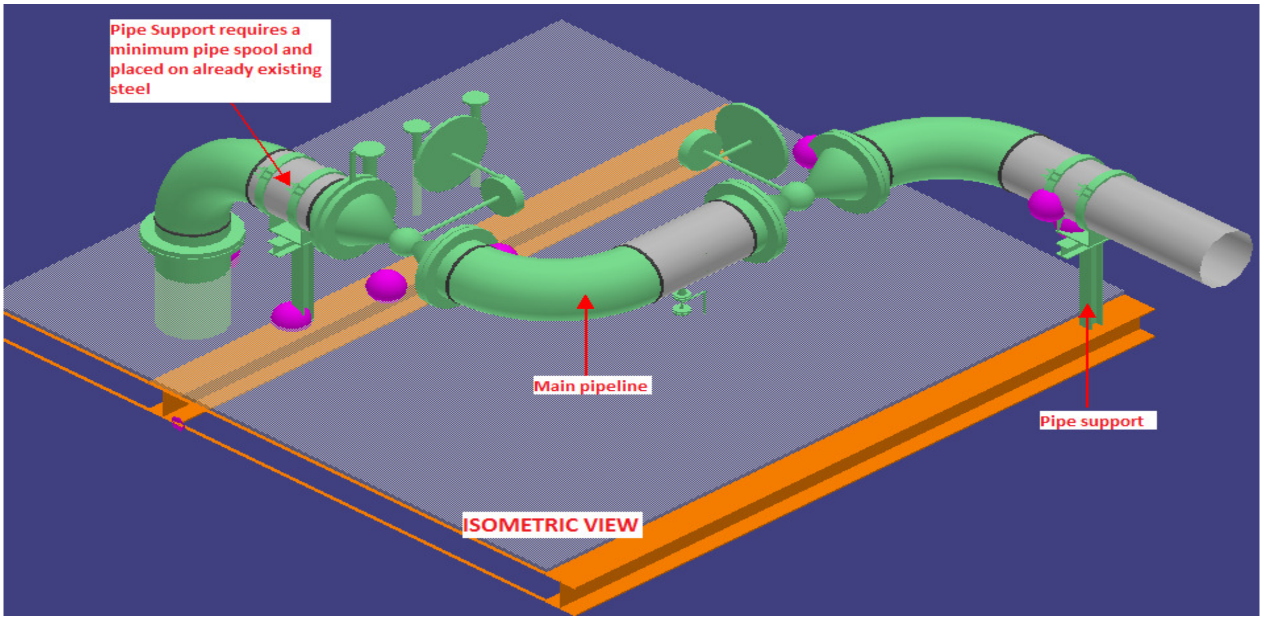



**Fig. 4.Spool and steel requirement for Pipe Supports**

### 3.2 DESIGN CHALLENGES FOR CSA ENGINEERS

Piping design engineers submit stress isometrics to stress engineers to analyse stress concentration points and support locations. Stress engineers locate support locations and suggest some routing changes to meet requirements. Designers locate logical supports and provide an input to CSA to provide additional steels for supports (Figure-3 and 4). Structuresare designed in such a way that the entire load throughout the module is transferred to foundation. Whenever additional steel or relocation or removal of existing steel is required by piping design engineers, it becomes a challenge or rework for CSA engineers. This problem becomes more complicated when additional cantilever beams are required at support locations between module and pipe rack. Generally, cantilevers are required from both module and pipe rack sides and it becomes complicated task for CSA because it increases ship loose steels. Cantilevers provided for supports between module and pipe racks are not transported along with modules because this additional steel is considered as ship loose material. This practice also increases field hours for fabrication at site, but the main objective of modularization is to relocate field hours to module yards.

## 4. HOW THEY ACHIEVE THIS MILESTONE?

Piping layout, stress analysis, support locations and steel required for supports are essential and independent requirements in a typical design of plant. But a better communication and interface is also required to provide supports for small and big bore pipelines. Designers can't avoid or change the support locations and they do change in layout if required. Also CSA engineers can't avoid additional requirement of steel or any change in existing structure, if required by piping design engineers. Thus it is always a milestone for piping and CSA design engineers to fulfil requirements of supports with a minimum use of ship loose steel. Section 4.1 to 4.3 describes the roles of Stress, design and CSA engineers to achieve the milestone pipe supports.

### 4.1 ROLE OF STRESS ENGINEERS

A better model review before providing final support locations as per stress calculation must be followed by stress analysers, so that they may have a good idea of surrounding structuresnear support locations. Selection of similar type of supports can reduce additional requirement of cantilevers. For example, a cantilever beam can be used as a base for support of pipe at elevation-A and also the same cantilever can be used for a spring support for a pipe at different elevation-B.Any scope of future expansion of pipe rack should be considered.

### 4.2 ROLE OF PIPING DESIGNERS/ENGINEERS

A good knowledge of pipe support size and selection of designers can minimise the required length of pipe spools for support. Routing of similar size of pipes at same elevation can minimise and supporting of small bore pipelines by big bore pipelines can minimise the requirement of cantilevers.

### 4.3 ROLE OF CSA ENGINEERS:

In case, if cantilever is required from both sides of module and pipe rack, any face to face cantilever should be avoided.

A detailed understanding of support size can be helpful for CSA engineers to use material in an optimised quantity.

## 5. CONCLUSIONS

Modularization is always meant to relocate field working hours to module yards. 1st Gen Modular Execution and 2nd Gen Modular Execution have been successfully relocating 20% to 50% of field hours to module yards hours. Once engineering and design is completed fabrication of modules, construction in filed, transportation and installation of modules in field etc. are major tasks. Before installation, the size of pipe racks is finalised thus the distance between a module and pipe rack is also finalised, hence providing supports between modules and rack is a long and challenging task for design and CSA engineers. To meet the requirements of stress engineers and to define actual meaning of modularization at the same time, CSA engineers aim to minimise ship loose steel. Thus it is not an independent task to provide supports for small bore lines. A better communication among four areas stress analysis, module design, CSA and pipe rack design can resolve all issues and can achieve all milestones with fulfilling all requirements of modularization and clients.

## 6. ACKNOWLEDGEMENT

The authors would like to acknowledge Fluor Corporation for its consistent encouragement and motivation to its employees for professional presentation and publication of papers in industry and academic forums.

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