NEW CONCEPT FOR STANDARDIZED LARGE-SCALE MODULAR LNG PLANT DESIGN

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Forecasts predict that global LNG demand will exceed supply by the early 2020’s - even when we consider the total capacity of plants currently under construction. However, supply could exceed demand if all planned LNG projects (pre-FID) were to be constructed and operated. Meanwhile some large scale projects are planned to be implemented at remote and/or harsh weather locations. Hence, fast and economically competitive supply to the LNG market will be a key success factor for these challenging projects.

To reduce schedule and cost, a standardized LNG plant design can be considered. Recently modularization has become a practical strategy for LNG plants to ensure safe and reliable construction at remote and/or harsh weather location where stick-built construction is unfavorable. However, most modular LNG projects have suffered schedule delay and cost increase due to several reasons.

Therefore, to implement the fastest delivery and the lowest CAPEX of an LNG project, one of the most effective concepts is to standardize modular LNG plant design. This paper presents analyzed results of the challenges for standardization and proposes the new concept of large-scale modular LNG plant design which has been developed by utilizing Chiyoda’s vast expertise through 40 years of providing EPC LNG projects all over the world. Achieving “the fastest project delivery” and “the lowest CAPEX” requires unique valuable ideas to minimize work volume at the construction site. We will present such ideas at the conference along with discussion of recent challenges and solutions.
INTRODUCTION

It is currently estimated that the global population will rise to over 9.8 billion by 2050. With this increase, it is explicit that energy demand will also increase. Furthermore, history has shown that the increase in energy demand exceeds the incremental increase in global population. Although the utilization of renewable sources of energy will steadily increase, fossil fuels will continue to be major source of global energy. Among the fossil fuels, natural gas and LNG will continue to play a vital role in countering global warming.

Forecasts predict that global LNG demand will exceed supply by the early 2020’s - even when we consider the total capacity of plants currently under Engineering, Procurement and Construction (EPC). However, supply could exceed demand if all planned LNG projects were to be constructed and operated.

Meanwhile some large scale projects are planned to be implemented at remote and/or harsh weather locations. In addition, a lack of skilled workers is manifesting in some countries due to a rush of construction. For these severe conditions, fast and economically competitive supply to the LNG market will be a key success factor to realize projects.

Chiyoda Corporation introduced CHIYODA LNG-X® in the LNG 18 conference to achieve the lowest CAPEX and fastest project delivery for stick built LNG projects. Now Chiyoda Corporation has developed the modular version of CHIYODA LNG-X® to cope with challenging conditions mentioned above.

NEW CONCEPT

For optimizing modularized LNG plant, the following new concepts are adopted which were inherited from CHIYODA LNG-X® concepts and further expanded in consideration of the special nature of a modularized plant;

1) Ready-designed block

In general, LNG process train consists of several units such as inlet unit, acid gas removal unit, dehydration unit, mercury removal unit, heavy hydrocarbon removal unit, and liquefaction unit. Although the design of respective units is not completely the same for every project because of client’s policy or preference, the basis of design is similar. Each unit can therefore be pre-designed by the experienced contractor as “Ready-designed blocks” based on the philosophy of safe operation and cost effectiveness. The basic design of the LNG train can be completed within a short time period as shown in Figure 1 just by connection of these blocks. Using this concept, although the LNG production or the operation efficiency may not be maximized, cost and schedule can be reduced.
2) Contractor standard job specification

Specifications prepared by the experienced contractor are to be applied to standardized LNG plant design in lieu of a client's individual specifications. The standardized design might deviate from the client's specifications, however no major problem is expected for project execution since the specifications prepared by the contractor are developed based on the vast experience of contractor and assure the necessary and sufficient safety and operability of plant.

Chiyoda standard job specifications are applied to the modular version of CHIYODA LNG-XR®

3) Eliminating the pre-requisite works at the early engineering stage

Reference is made to Figure 2 below which compares four example project schedules. The EPC bidding stage in the "Dual FEED & EPC Contract" schedule can be reduced as EPC cost estimation is executed on the basis of each bidder's design. If the client utilizes an alliance contract for FEED design, the intermediate stages from pre-FEED to FEED such as FEED bidding, bid evaluation and the FEED contract can be eliminated. At the early stage of a project (pre-FEED), if a client decides to adopt the standardized design and the same contractor executes through FEED and EPC, the contractor can offer the fastest project delivery.
In addition, the new concept applied to the modular version of CHIYODA LNG-XR to achieve the lowest CAPEX and the fastest project delivery is as follows;

4) Minimum work volume at construction site

A) Minimization of welding work volume around main refrigerant compressor

Even though modular construction is applied, there is much site welding work for hook-up between modules and stick built items.

In past modularized projects, it was common to consume many man hours around the main refrigerant compressor. Therefore welding work volume (dia-inch, hereinafter DI) at site related to main refrigerant compressors per one process train were re-evaluated as shown in Table 1 below:

<table>
<thead>
<tr>
<th>Total welding work volume at site for one process train (DI) (a)</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hook-up between Modules (b)*1</td>
<td>Incl. above</td>
<td>14,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Welding work volume at site related to Ref. Comps (DI) (c)</td>
<td>13,600</td>
<td>19,600</td>
<td>15,600</td>
</tr>
<tr>
<td>Ratio (c) / ((a) + (b))</td>
<td>49 %</td>
<td>51 %</td>
<td>26 %</td>
</tr>
<tr>
<td>LNG Capacity (MTPA)</td>
<td>4.0</td>
<td>4.2</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Note *1) Dia inch is calculated based on single weld hook-up between Pre-Assembled Rack (PAR) and PAR, double weld hook-up between PAR and Pre-Assembled Unit (PAU).

Table 1: Comparison of Welding Work Volume at Site
It is confirmed that site welding work volume related to main refrigerant compressors is approximately 50% of total site work volume.

Therefore the main focus area to minimize the welding site work volume is around the main refrigerant compressors.

How can we shift welding site work volume around main refrigerant compressor to the module yard?

Of course, if the components of the main refrigerant compressors are delivered to the yard and assembled together with PAU, welding site work volume can be reduced significantly, however we noted, in this case, total project schedule would be extended. Consequently the fastest project delivery could not be achieved.

If the components of the main refrigerant compressor are assembled on a common skid at vendor shop, some of the work around main refrigerant compressor can be reduced, however the majority of the welding site work for refrigerant piping is still left.

As a result of case study, it was concluded to apply the following solutions:

- Assemble the main refrigerant compressors components on the common skid
- Deliver the common skid to site and integrated into PAU

Note *2) Air-intake duct and exhaust stack will be installed after skidding.

Figure 3: Main Refrigerant Compressor Installation Sequence
B) Layout optimization

In past modularized projects, piping hook-up work volume between PAR and PAR were approximately 3 times larger comparing to the one between PAU and PAR, since there are many large bore straight pipes in PAR which do not pass through the PAU. Furthermore, the number of joint locations between PAU and PAR were 4 times larger compared to those between PAR and PAR.

Based on past project experience, the following measures are adopted in order to reduce site welding work volume;

- PAR is as long as practical to minimize number of joint locations between PARs which has large site welding work volume.
- PAUs are integrated with PARs as much as practical to reduce the number of joint locations.

Figure 5: PAU/PAR integrated module concept
This is achieved by optimizing the layout and targeting a minimum number of connections. We have revised the conventional “fishbone” layout by placing PAUs on both sides of a main straight pipe rack.

C) Minimize electrical and instrument work

In order to minimize cable laying work at site, following concepts are applied:

- Install Local Electrical Room (LER) on each PAU and PAR
- Install Local Instrument Room (LIR) on each PAU and PAR
- Perform pre-commissioning work at module yard

Figure 6: LER/LIR mounting on module concept

STANDARDIZED LARGE-SCALE MODULAR LNG PLANT DESIGN

Chiyoda Corporation has developed a standardized large-scale modular LNG package, “CHIYODA LNG-Xm Japan™”, using the new standardization concepts described above and developed from Chiyoda Corporation’s unparalleled expertise and experience in global LNG plant engineering and construction. This concept will minimize site work and optimize the “Plug & Play” model.

CHIYODA LNG-Xm Japan™ has been developed on the following basis;
- **Design Package Capacity**: 7 Million Tonnes Per Annum (MTPA) at cold climate region
- **Liquefaction Process**: Propane Pre-cooled Mixed Refrigerant Process
- **Refrigerant Compressor Driver**: Trent-60 DLE or LM6000PF + x 4 (2 strings)
- **Cooling**: Air cooling
- **Specification**: Chiyoda Standard Job Specification

CHIYODA LNG-Xm Japan™ derives its name from its module layout resembling the Japanese archipelago.

Figure 7: Overview of CHIYODA LNG-Xm Japan™

Through the 3D model development adopting the concepts mentioned above, site work volume for pipe welding and cable laying has been compared to a past project which applied conventional measures. The results are shown in Figure 8;
CONCLUSION

The importance of LNG as a source of energy will continue to grow in response to escalating global clean energy demand. There are many proposed new LNG facilities but only the most competitive of those projects currently under planning stage will be realized. Consequently “the lowest CAPEX” and “the fastest project delivery” are key criteria to realize successful future LNG projects. Design standardization with Chiyoda’s new “large scale modularization” concept is an essential element to achieve these two vital targets. As the No. 1 LNG contractor, Chiyoda Corporation will continue to support clients and contribute to the realization of successful LNG projects.

ACKNOWLEDGEMENTS

We would like to thank Takeshi Kaji for supporting concept development by establishing the 3D model. His unconventional ideas and diligence form the basis of the standardized modular package CHIYODA LNG-Xm Japan™.

REFERENCE

[1] Standardization of LNG Plant Design Based on a New Concept, Toshiya Momose, Chiyoda Corporation, LNG18