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PETROBRAS P-55 - A NEW APPROACH FOR THE TOPSIDES DESIGN

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Abstract

In July 2007 PETROBRAS awarded Gusto BV the Front End Engineering and Design (FEED) for the re-design of the Topsides for PETROBRAS-55 Production Platform ("P-55") seeking simplification, reduction of costs and schedule.

The PETROBRAS-55 will add an impressive 180 000 barrels oil processing capacity to the Roncador Field in the Campos Basin. Despite its large capacity the functions to be fulfilled on board can be performed by methods well known in the oil industry. Oil dehydration by gravity and electrostatic separators, oil stabilization through heating and depressurization, carbon dioxide removal out of gas through adsorption by amine, gas dehydration through absorption by glycol, produced water treatment through hydrocyclones and gas flotation, etc.

Offshore operations in general, due to their independent (self reliance), remote location, limited manning and expertise, etc., need to be as rugged, robust, lean and simple in its set-up and operation as possible. The (front end) engineering plays an essential role in the Endeavour to obtain these characteristics on an offshore unit. The initial configuration is perceived as one of the key elements that will determine to a great extent the feasibility of the much sought simplicity.

Since the basic design does not cover the complete project the approach used to meet the objectives was to deliver a safe, operable and lean design, it focused on simplifications. The mainly technical approach is described below.

1. Introduction

The "P-55" will be a Semi-Submersible Production Platform capable of processing 180 000 bopd and a total liquids of up to 200 000 bpd, process (compress, remove CO_2, H_2S and dehydrate) up to 4 million Nm^3/d of gas, inject 290 00 bpd of water, including all the required utilities to support the facility. It will be located in the Campos Basin on the 3rd Module of the Roncador Field, in the vicinity of Module 1A – Phase A (FPSO Brasil), Module 1A – Phase B (Semi-submersible P-52) and Module 2 (FPSO P-54) in water depth of approximately 1800 m.

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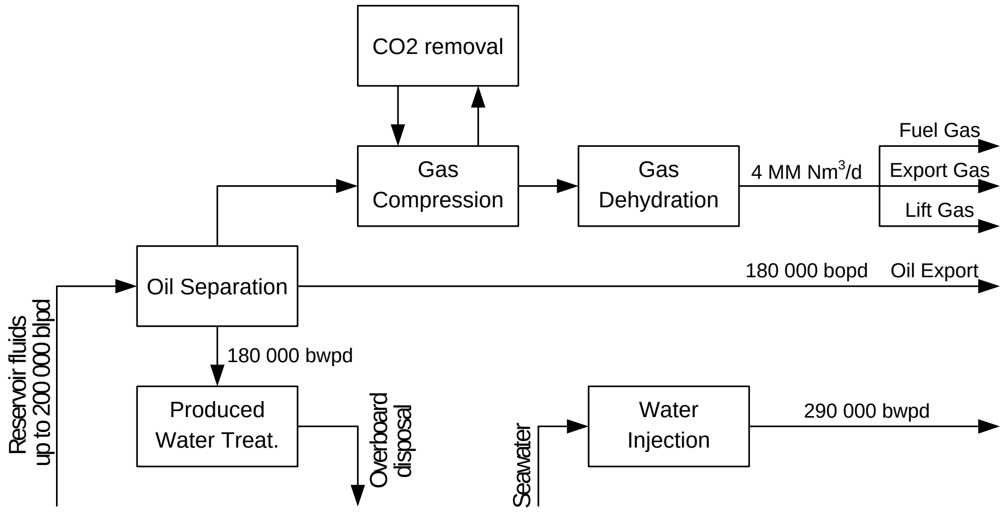

Figure 1. Basic block diagram of the P-55 processing facilities

The Hull dimensions and shape (outside the scope of subject basic engineering project) designed by PETROBTAS R&D Center, were optimized for minimizing vertical motions to allow the use of Steel Catenary Risers.

For the re-design of the P-55 processing facilities (Figure 1), PETROBRAS have issued functional specifications and allowed the use of industry standards rather than company directives / guidelines. Furthermore, in order to ensure the incorporation of lessons learnt both from PETROBRAS and SBM a combined engineering team was set-up and operational reviews consistent with the Basic Design were organized

Whilst maintaining the safety and the functionality of the Unit, the approach described below was used to achieve the project technical objectives.

2. **Conditions for a lean and simple design**

Simplicity is considered the foundation for safe, efficient, cost effective and operable designs, and does not necessarily mean that the functionality and flexibility are impaired.

In order to achieve simplicity in the design of the unit, it is believed that, among others, the following conditions need to be fulfilled:

2.1 Functional specifications

Functional specifications allow the designer to select the techno-economic optimum of various solutions available in the industry and allows the suppliers to introduce their expertise, whereas prescriptive specifications miss such opportunities and in some cases can even miss developments in the industry. For the P-55 with its classic functions on board, there is a diversity of options to be adopted.

The use of functional specifications, further, allows better assessment of the overall plant. Rather than specifying individual components or functions and their performance, this more ‘holistic approach allows the supplier, operator and designer to consider the interaction between the various components, and the possibility to implement solutions that improvement of the overall performance.

2.2 Design philosophies

Agreed design philosophies are considered essential in the design since they set criteria to be followed. Examples of such philosophies are: safety, equipment sparing, constructability, material handling, layout, etc. For the subject project SBM’s ‘CES’ Corporate Engineering Specifications (including philosophies) were used to guide the design. The CES specifications are based on industry standards supplemented by the operational feedback from the SBM fleet. This set of documentation was discussed with PETROBRAS before the start of the project.

2.3 Mature basis of design

A well defined (‘frozen’) basis of design keeps the focus of the project team on the engineering process (safety and operability) rather than on updating the documents to incorporate changes during the project. Since changes affect various engineering disciplines there is always the risk that project team members are not informed properly about the impact, making the control of the project difficult. Furthermore, making the documentation set consistent with the latest changes is a time consuming activity.

The project execution strategy calls for a peer review of the design by process engineers, operations, etc. in an informal setting to facilitate free exchange of ideas. This meeting is scheduled prior to the HAZOP such that major changes/clarifications can be addressed prior to the HAZOP. This exercise makes the HAZOP more relevant, more to the point as the team is more familiar with design intent, constraints, etc. The completion of the HAZOP is the condition used to freeze the design.

2.4 Integrated teams

Due to the complexity, and the many inter-disciplinary interfaces of a project of the magnitude of P-55 it is important that team members share and challenge openly and pro-actively the basis of discipline decisions. Open discussions on the impact for other disciplines is important not only to secure team commitment but also to arrive at solutions that can be incorporated in the design. An open discussion also helps team members to gain insights in areas outside their own discipline, helping to better understand each other constraints.

For the P-55 Topsides FEED, PETROBRAS engineers were embedded in the design team to support the common project effort and objectives. This feature proved to shorten the communication lines between Contractor and Company. In addition it creates commitment to implement, in the next phases of the project, the simplifications achieved. Furthermore the input of the operations staff during the reviews proved to be valuable feedback for the operability and design optimization of the unit.

2.5 Symbiosis between engineering and procurement

In order to have the reliability and cost-effectiveness benefits out of suppliers mature standard designs it is necessary that the components are left as authentic as possible. In other words rather than having the suppliers adapting their products to suit the project, the project should accommodate solutions available on the market.

In the FEED phase the configuration of the plant has been set up to accommodate, where possible, the equipment of suppliers on PETROBRAS vendor list. It is to the Detail Engineer, assisted by their Procurement, to incorporate market solutions to the project.

2.6 Operations

Compared to the initial design it was decided to reduce the manning level of the P-55 from 200 to 100 Personnel on Board. This reduction is consistent with an operations approach in which the operators do have an overall responsibility for the plant rather than only perform certain tasks. This means that operators responsible for certain systems or areas also are responsible for housekeeping, small maintenance, etc, as in the SBM fleet.

3. Design approach

During the basic engineering (FEED) phase the approach to achieve the project objectives was basically a technical approach, the main elements are:

3.1 Equipment count

Reducing the number equipment to a minimum will also reduce the number of connections, supports, etc. The criteria for such exercise needs to be based on an agreed Sparing Philosophy in order to maintain minimum redundancy in the plant. Other criteria include design margins through design philosophies, etc.

High capacity equipment is generally large to reduce the amount of parallel units, but within the sizes available on the market to ensure standard, mature designs. Combining functions (parallel rather than in series), as presented in Figure 2, is another way to reduce the number of items required to fulfill the functions on the platform, and some cases it reduces the overall capacity of the system.

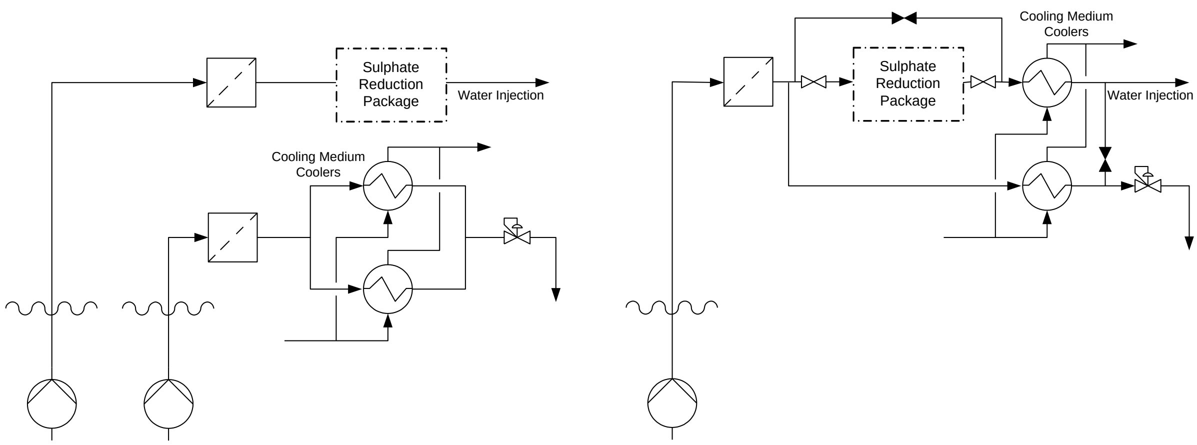

Figure 2. Example of equipment reduction through combination of functions

3.2 Reduced footprint

The first example of significant footprint reduction that was implemented was the rearrangement of the heat exchangers relative to the High Pressure Separators presented in Figure 3. This change enables:

- Usage of heat exchangers that are less resistant to the effects of slugging such as Plate and Gasket Heat Exchangers (small footprint),
- Improved het transfer due to upstream separation of gas, therefore it allows the use of less transfer area due to smaller exchangers,
- Lower heating load due to the bulk separation of produced water upstream of exchangers,
- Deletion of the Compression Suction Cooler,
- Smaller equipment requires less Fire Water.

The above benefits are at the expense of :

- Less efficient Oil/Water separation in High Pressure Separation Stage,
- Less efficient Produced Water Treatment (de-oiling).

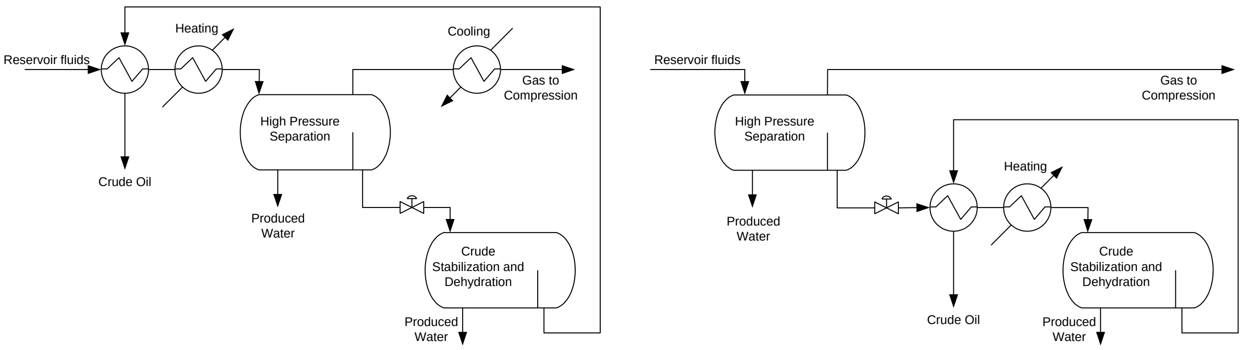

Figure 3 Relocation of heat exchangers relative to High Pressure Separator

Another example of footprint reduction was the choice for compressor strings with a single (and larger) driver, capacity control through suction throttling rather than variable speed, and the usage of Printed Circuit Heat Exchangers (PCHE's)rather than Shell and Tube ones. Suction throttling control, at nominal capacity is simpler and requires lower electrical loads, is much leaner as far as equipment count is concerned, but less efficient at turndown. PCHE's do require far less footprint, at the expense of better quality (cleanness) of the cooling medium.

3.3 Safety

The lower equipment count leads to a less congested platform since the area on cellar and main deck were a design premise for the FEED), making redundant the need of blast walls on the platform. Another significant benefit of the lower equipment count is the lower fire water demand.

Despite the division into hazardous and non-hazardous areas, all equipment on open areas are specified as Ex-rated. This feature gives the design and construction far more freedom as far as the usage of deck openings is concerned (e.g. staircases, cable and pipe penetrations, etc.) with respect to gas dispersion in the case of a leakage.

3.4 Electrical and Instrumentation

The electrical design does not make use of an intermediate voltage. The reduction in voltage levels requires less transformers and therefore less footprint and utilities (Ventilation and Air Conditioning). These benefits require some electrical drivers to be equipped with dedicated transformers.

The instrumentation design is based on local rather than centralized control. This approach has a significant impact on the Input / Output (I/O) count, resulting in a smaller control system and Instrument Equipment room, less maintenance and higher reliability, at the expense of local intervention.

3.5 Constructability

The approach used to set up the layout of the plant was based on the lifting constraints at the potential construction yards. Furthermore a balance between skid , stick and modular building can reduce the construction time by allowing construction at multiple locations:

- Skids for items such as the Power Generation units and large pumps (Water Injection and Crude Oil Export),
- Modules for systems with high piping and high equipment density. High pressure systems, in order to limit filed welds are also preferably mounted on Modules,
- Stick building for systems with low piping and equipment densities.

4.0 Outcome of the P-55 Topsides FEED

The comparison between the former and the actual designs can be summarized as follows, in Table 1.

Table 1. List of main differences between previous and actual project

P-55 Topsides			
	Previous project	Actual project	Impact
Accommodation (Personnel on Board)	200	100	Less cabins and offices
Flare structure	Boom (100m)	Tower (70 m)	Smaller structure and foundations
Construction	Modular	Hybrid (skids and modules)	Less steel and reduced schedule
Process	Heating upstream of High Pressure Separator	Heating downstream of High pressure Separator	Less footprint and weight
Compression	3 stages single driver Capacity control through hydraulic coupling.	3 stages single driver Capacity control through suction throttling	Less footprint and weight
Heat Exchangers	Shell and tube	Plate and Gasket (low pressure liquids) and Printed circuit (high pressure gas)	Less footprint and weight
Layout	Tween Deck	Local Platforms	Less footprint and weight
Fire Fighting Pumps	3 x 2350 m^3/h (3x50%)	2 x 2000 m^3/h (2x100%)	Less footprint and weight

Figure 4 presents an overview of the P-55 3D model.

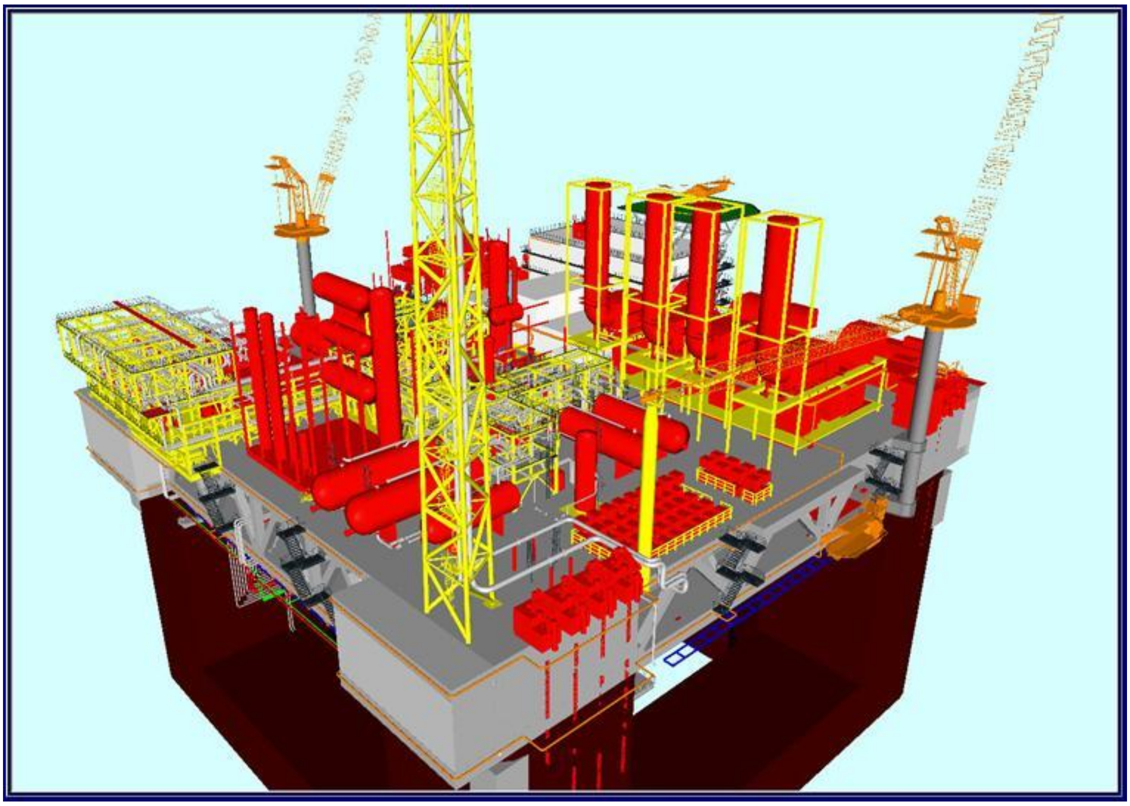

Figure 4. P55 3D model

The lean and simplified design achieved a weight reduction as listed in Table 2 below:

Table 2. Weight comparison between previous and actual design

P-55		
	Previous design (ton)	Actual design (ton)
Topsides (process plant, utilities and accommodation)	21 700	14 000
Deck Box (cellar deck and the module support truss deck) [1]	10 600	9 000
Total	32 300	23 000

[1] Deck box design is not part of the subject project

5.0. Acknowledgements

Thanks to all who helped to bring to reality the concept of a leaner, operable and above all a safe design for the PETROBRAS-55, from those who conceived the idea up to those who are realizing it. And in special our appreciation to the PETROBRAS resident team who not only left their family and friends back home during the project period, but also endured a wet and cold winter on northern hemisphere in lieu of a hot summer south of the equator to pursue a new start for the P-55.