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Research and Application of Gravel Packing Construction Method for Offshore Horizontal Well

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Abstract: Horizontal well technology can effectively increase the flow area of oil and gas wells, which in turn increases the production per well. However, horizontal wells also bring serious sand-out problems while increasing oil and gas well production. Offshore oil and gas wells are more expensive to develop and in order to provide production cycle they all carry out prior sand control to prevent the well from being scrapped due to sand out. At present, the horizontal well gravel filling process is mostly used offshore, which is a complex process and involves the cooperation of many parties. The process of horizontal well gravel packing operation is less standardized due to the influence of drilling platform, well condition and marine environment. This paper analyzes the advantages, disadvantages and adaptability of the operation method of vessel support and the operation method of platform support. The study of standardization of processes such as equipment arrangement, equipment fixation, and construction process under the two operation modes is proposed. The focus is on the equipment arrangement and fixation under the ship operation mode, while the standard practice of emergency evacuation of ships is proposed. Without considering the variability of the marine platform, the design of equipment arrangement under the horizontal well gravel fill dependent platform operation mode is studied. The application in the field and the analysis of the timeliness prove that the equipment arrangement standard under the platform-dependent operation mode meets the requirements of offshore oilfield construction and can provide a reference for the standardization of gravel packing and sand prevention completion.

Keywords: Horizontal Well, Gravel Packing, Equipment Layout, Standardization, Fixation

1. Introduction

China's offshore oil and gas resources are abundantly stored [1, 2], but the development of offshore oil and gas is slow due to the ocean weather, marine conditions, exploitation technology and other factors. At present, offshore oil and gas development is mainly in Bohai Bay, the South China Sea and the East China Sea are in the early stage of exploitation. Due to the high cost of offshore field exploration, long-term stable production is the main factor to be considered when exploring offshore oil and gas wells.

Horizontal wells are currently preferred when drilling offshore oil and gas wells [3, 4]. Horizontal wells can effectively increase individual well production and reduce overall exploitation. However, horizontal wells can exacerbate sand problems while increasing the production of producing wells. Therefore a pre-emptive sand control method is adopted to ensure long-term production of the well. At present, there are mainly two processes for offshore sand control completion, one is the independent screen tube sand control technology, which is applies to the case of less sand in the formation, and the other is the horizontal well gravel-packing sand control technology, which is suitable for the case of more sand in the formation. Gravel packing technology has been widely used because the process has been proven to be effective in sand control in horizontal wells over a long period time [5, 6].

Compared with sand control in onshore oil and gas wells, sand control in offshore horizontal wells with gravel packing is more difficult [7, 8, 9]. Many factors lead to the lack of a standard operating procedure for offshore horizontal well gravel packing operations due to the high influence of sea conditions and weather, small construction work area, high equipment placement density, and fast construction pace. Each operation has to carry out site research and plan

determination so the operation preparation period is long. In order to further improve the efficiency of offshore sand control construction and standardized operation, a study on the standardized construction of offshore sand control with horizontal well gravel packing was conducted.

2. Comparison of Gravel Filling Operation Methods in Offshore Horizontal Wells

At present, there are mainly two ways of offshore horizontal well gravel filling operation, relying on vessel support and relying on platform support for operation. Vessel operation method is that the anti-sand pumping equipment is arranged on the deck of the engineering vessel, and the vessel berths at the operation platform to implement gravel filling. The use of ship operations is influenced by ocean weather and sea conditions. In the case of bad weather, it causes the ship cannot berth the platform to implement gravel filling construction, and this situation will increase the time of horizontal well sand prevention and reduce the efficiency of construction. If a bare-hole horizontal well cannot be constructed in time, it will increase the vacant time of the bare section and affect the stability of the well resulting in great uncertainty in the lowering of the anti-sand pipe column and the gravel filling operation.

The platform support operation method is to lay out the equipment on a fixed offshore oil recovery platform or a movable drilling platform to carry out gravel filling. This type of operation is less affected by weather and can guarantee the continuity of construction. However, due to the different sizes of platform decks, large differences in platform patterns, deck bearing capacity, platform crane tonnage, etc. can cause difficulties in arranging equipment into position. This type of operation requires advance layout, a long construction preparation period, and possible cross-operation.

The two operation methods of ship support and platform support were compared, each with advantages and disadvantages. Their advantages, disadvantages, and adaptability are shown in Table 1.

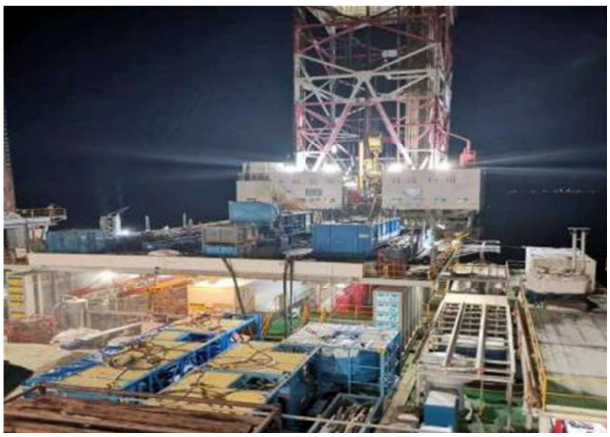

Figure 1. *Construction site plan relying on vessels and platform support.*

Table 1. *Table of advantages, disadvantages and adaptation scenarios of platform operation support and ship operation support.*

Operation method	Advantages	Disadvantages	Applicable situation
Vessel Support	(1) Materials, equipment arrangement, and liquid mix can be carried out earlier. (2) It does not affect other work carried out on the platform and there is no cross operation. (3) After the engineering vessel is docked to the platform, only a flexible pipeline needs to be connected to the wellhead, which is convenient and fast.	(1) Vessel berthing platform is greatly influenced by wind, tide and other weather factors. (2) Long time docking platform during operation, affected by weather and sea conditions, there are safety risks.	(1) The platform area is too small for the equipment to be placed. (2) The platform crane tonnage is small, and the equipment cannot be lifted. (3) Uninhabited guarded platform.
Platform Support	(1) Reducing the use of transport vessels and liquid storage tanks. (2) The construction is less affected by the sea condition after the equipment is in place on the platform. (3) Make full use of platform mud chamber and liquid dispensing system to realize reuse of filling liquid.	(1) Frequent lifting operations in a small space with high safety risks. (2) Sand prevention construction and other operations often have conflicts of site occupation. (3) There is a possibility of cross-operation.	(1) The operating platform area is large enough to meet the equipment placement, and the crane meets the lifting conditions. (2) The operating environment is highly variable and the sea state is more serious. (3) New wells are put into production and supported by the drilling platform.

3. Study on Standardized Operation of Offshore Gravel Filling

3.1. Standardized Operation Study of Ship Support Methods

Research on standardization of ship support construction methods is currently focused on two areas [10, 11]: deck layout and fixing of equipment, and emergency evacuation of ships. If a special anti-sand vessel is not used, the equipment needs to be laid out on the deck of the vessel and especially fixed to ensure operational safety. The vessel berthing platform in Bohai Bay uses the bow anchor and stern cable to achieve stability during the operation. Even for vessels

equipped with DP power positioning, this type of berthing is generally recommended to ensure the safety of operations. Deep-sea oil and gas well gravel filling is supported by ships, and it is recommended to use ships equipped with DP2 or above power positioning for construction. The vessel berthing platform basically determines the overall layout of the equipment, from the stern to the bow in the order of high pressure area, medium pressure area and low pressure area, as shown in Figure 2. Such a layout achieves zoning management of the deck, with different risk prevention measures for staff in different pressure areas.

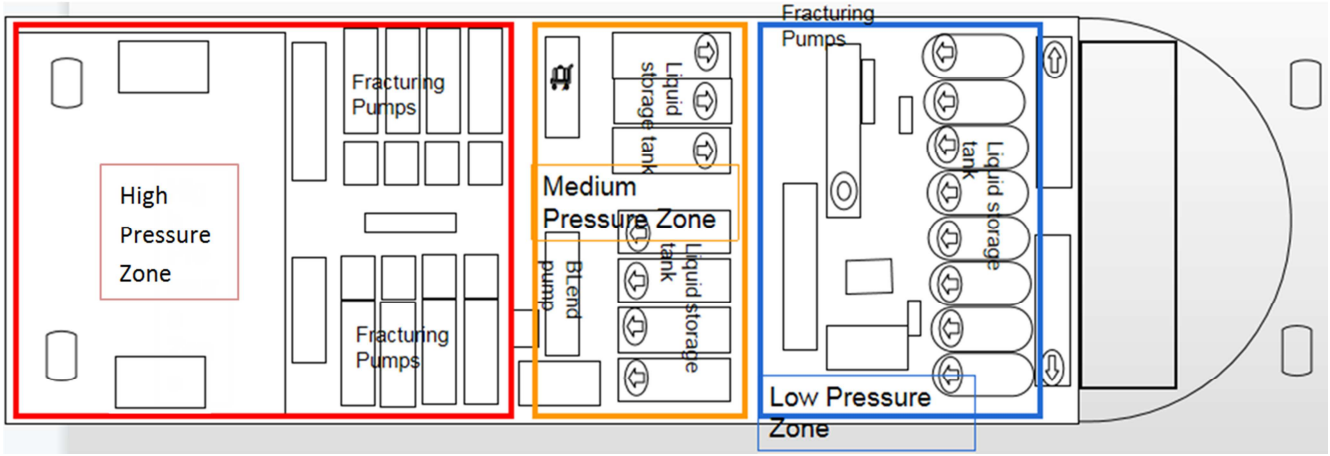

Figure 2. *Schematic diagram of ship deck layout.*

The layout of high - medium - low pressure area is the basic idea of the layout of engineering ship deck equipment. But the way the equipment is arranged ultimately depended on the results of the vessel's stability calculations.

The vessel stability calculation is to calculate the static stability of the vessel and the dynamic stability of the vessel during travel based on the weight and location of the equipment after determining the layout of the equipment on deck. For the ratio of type width to type depth 2.5, the cross-tilt angle corresponding to the maximum principle arm in the ship stability curve can be less than 25°. But not less than 15°, other reference to the relevant standards.

If the ship stability calculation does not meet the requirements, first consider adjusting the equipment layout, and then carry out the ship stability calculation again. If the calculation cannot meet the stability requirements, it is necessary to consider changing the engineering vessel to ensure the safety of the operation [12, 13].

After the equipment is placed on the ship deck according to the stability calculation, the equipment on the deck also needs to be fixed. Through the calculation and analysis of the force on the equipment, the fixation between the equipment base and the equipment is shown in Figure 3.

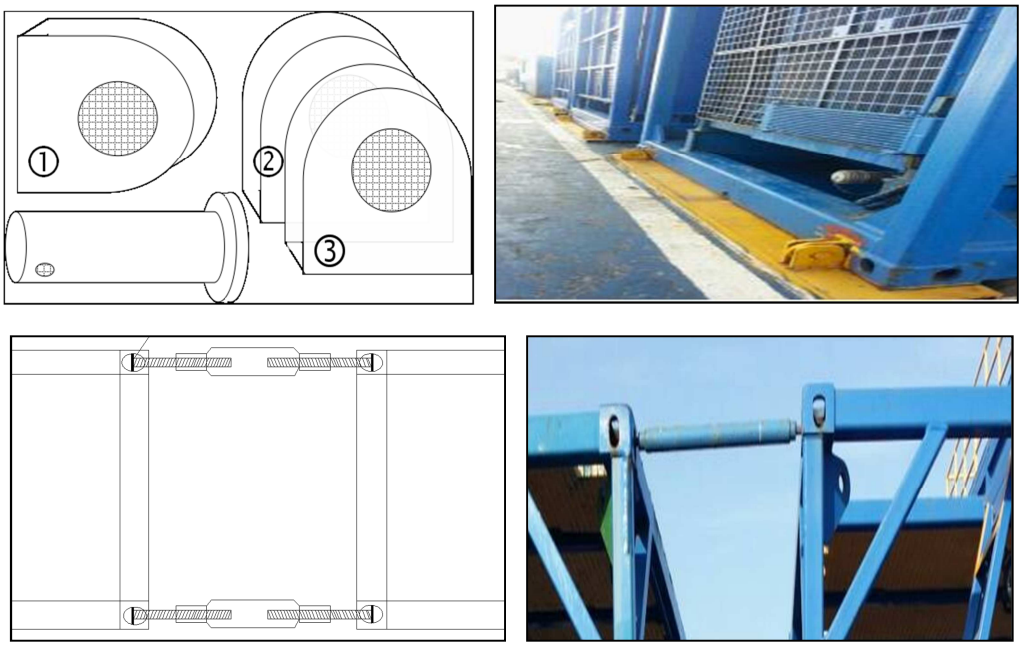

Figure 3. *Fixing method drawing of equipment arranged on deck.*

Vessel operation mode is greatly influenced by sea state. If there is a sudden weather change during the construction process [13], the construction vessel needs to leave the platform as soon as possible to ensure the safety of the vessel and the platform.

If there is a sudden weather change during the construction, the vessel needs to leave the platform as soon as possible to ensure the safety of the vessel and the platform. During emergency evacuation, the high pressure pipeline connected between the ship and the platform is the main difficulty. A slower removal of this pipeline would increase the evacuation time and prevent timely evacuation. At the same time, the disconnection method is not reasonable and may cause marine environmental pollution.

Quick release device is a device used to quickly disconnect high pressure hoses connected to ships and platforms in case of emergency, which is hydraulically remote controlled and also has the function of self-closing after disconnection to prevent possible marine environmental pollution caused by liquid flowing out of the pipeline [14, 15]. The quick disengagement device, as shown in Figure 4, is installed in the aft section of the ship and can be disconnected and self-sealed within 10s by remotely operating the hydraulic control station during emergency evacuation.

Figure 4. *Quick release device and installation diagram.*

3.2. Research on Standardization of Platform Support Operations

The standardized research content of platform operation support method mainly focuses on the layout of equipment. It is difficult to determine the standard way of layout because of the different size of each rig, the difference of layout and the influence of deck carrying capacity. The study on the standardization of platform support operations is mainly from the perspective of process flow. First, the equipment is laid out in an undifferentiated manner according to the construction process, and then local adjustments are made according to the differences in each platform. Analyze the role of equipment and the sequence of completion fluid during horizontal well gravel packing operation, and compile a flow chart of horizontal well gravel packing process when supported by platform. The next step is the layout of the equipment placement according to the platform deck conditions and the requirements of each process step.

Each platform has a main deck and a tube stack deck, with the tube stack deck being higher than the main deck according to the frequency of use. According to the calculation of deck strength, the load per unit area of the main deck is greater than that of the tube stack deck. The pumping equipment needs to be in place in advance for installation and commissioning, so it needs to be in place at the platform in advance. Because of the large weight of pumping equipment and the need to use the pipe stack deck for wellbore treatment before gravel filling of horizontal wells, the main pumping layout was placed on the main deck without affecting other operations. Other supporting equipment is convenient and simple to connect, and can be put on the ship deck first, and then on the platform for equipment layout after the tube yard deck is cleaned up after the anti-sand pipe column is put into the well.

After the basic equipment layout plan is determined, the layout can be made according to the platform deck condition and operational characteristics. At the same time, it is necessary to consider the carrying capacity of the marine equipment transportation vessel, the sequence of the process, and reasonably arrange the equipment transportation, lifting, and arrangement of sand prevention equipment. And the most important point, when the equipment layout in place, to avoid occupying the platform safety emergency routes.

4. Offshore Horizontal Well Gravel Filling Operation Application

Offshore X well needs to be completed with horizontal well gravel filling, considering that the time has already entered winter and sea conditions and weather change frequently, it is not suitable for ship-supported operation method. Offshore X well needs to be completed with horizontal well gravel filling, and the time has already entered winter, with frequent changes in sea conditions and weather, etc. Well X is a bare borehole horizontal well, if there is a ship cannot berth in time to operate will be the well and so on stop, resulting in bare borehole section may be shrinkage or collapse of the wellbore, so the operation method must be continuous. After collecting platform-related information and conducting preliminary layout, the basic conditions for platform equipment layout

were met. Platform support for construction can circumvent the influence of weather and sea state factors on gravel filling construction, so this operation method was adopted. After determining the operation mode, a detailed analysis and preliminary layout of the platform drawings and equipment parameters were carried out. As the platform can be used to store sand-carrying fluid compartment is small, the horizontal section of the well is estimated 800 meters, to ensure the smooth construction, two 40 square mobile fluid tanks were added and the flow of fluid was planned in detail. The layout of the equipment was planned in advance according to the platform drawings and equipment dimensions. The planned layout was adjusted on site, and the actual placement is shown in Figure 5.

Figure 5. *Actual placement of platform main deck and pipe stack deck.*

5. Conclusion and Suggestions

(1) Vessel support and platform support each have their own advantages, but at the same time each has its own disadvantages, should be based on the scale of operations, construction technology, sea weather conditions, a reasonable choice of operating methods.

(2) Improving the standardized process of offshore horizontal well gravel packing operations can improve operational efficiency, layout standardization and rationalization.

(3) The standardization of offshore gravel packing has only achieved the standardization of operation mode selection and equipment layout and process, and it is necessary to continue to study and explore the standardization of the whole process to improve the degree of standardization and operation efficiency.

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