# GENERAL GUIDANCE FOR THE DESIGN, FABRICATION AND INSTALLATION OF JACK-UP PLATFORMS

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## ABSTRACT

*Variety of offshore structures are fabricated worldwide in order to be used in a variety of water depths, environments and for a variety of functions. Jack-up platforms were fabricated since the middle of 20 centuries, and have become the most widely used offshore drilling unit for oil/gas exploration and development purposes. In order to be more familiar with Jack-up platforms, this paper is devoted to giving a brief description of the process of Jack-up platforms design and fabrication. This paper also reviews the factors that affect the design of Jack-up platforms. When Jack-up platforms reach their operation location, they need to be installed for oil/gas exploration and other purposes, so a brief description of the process of Jack-up platforms installation is also presented. Eventually, a number of a conclusion is delivered to know where the Jack-up platforms are used.*

**Keywords:** Jack-up platforms, design, analysis, fabrication, installation.

## INTRODUCTION

There are many types of offshore platforms that are used to investigate and produce oil. The jack-up platform is one of the most applicable platforms used for these purposes. The Jack-up platform should be designed in such a way that it can sustain the applied loads safely for the design lifetime. Jack-up platforms are like a ship having long legs that can be placed according to its location. When Jack-up platform reaches its destination, the legs of the platform are jacked down, and the hull of the platform is heightened to allow movement of water under it., The most commonly used type of platforms in the world are Jack-ups. They can be used for drilling in Variety of water depth up to 500ft.

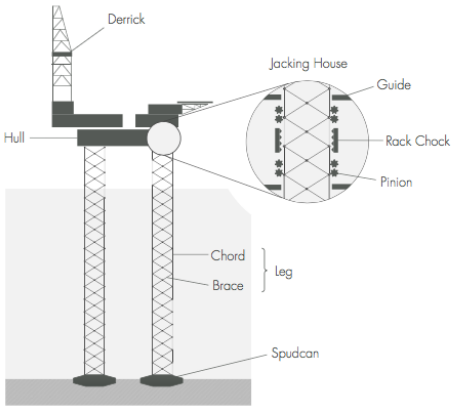


Fig. 1. General assembly of a Jack-up platform and its components (Koole, 2015)



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Jack-up platforms are used where the depth of water is not greater than the height of Jack-up platform legs regardless the hull height and the gap between the hull and surface of the water in the operation place. During transportation, the platform's hull is on the surface of the water and its legs are sticking high into the air. Jack-up platform structures are almost fabricated by different grade of steel such as high strength steel and mild steel. The chords of Jack-up platform's legs are tightened by bracing in the shapes of K, V, inverted V and X. Fig. 1 illustrates a general assembly of a Jack-up platform and its components.

## HISTORICAL OVERVIEW

A total of 641 Jack-up platforms were made from 1950 to 2012. Asia fabricated 45% of the total number of Jack-up platforms during 1950 to 2012, U.S. contributing 37% and Western Europe 8%. Since 2000, U.S. fabricated 14%, Asia contributing 70% and 16% in all other countries.

U.S. began to fabricate Jack-up platforms in the mid to late 1950's and was controlled by U.S. shipyard in the 1960's. US. companies started to invest in Singaporean shipyard so that they reduced the cost of transportation for that region in the early to mid-1970's. At the same time Western Europe, Japanese and Canadian companies begun to compete in the fabrication of Jack-up platforms so the fabrication market growth significantly.

The price of oil was increased in 1970 and early 1980's which led to greater demand for Jack-up platforms' improvement and numbers, So new market participants come out to fabricate Jack-up platforms by the mid-1980's. France, Singapore, Russia, Brazil, and Romania had offered platforms too. The oil price fell down again in 1980 to 1985 so that the demand to fabricate new Jack-up platforms had decreased. 244 Jack-up platforms were fabricated during this period. However, between 1985 to 2000, only 30 platforms were fabricated. Later on, the demand for fabrication of Jack-up platforms went up a little until 2010.

## DEMAND FACTORS

The demand for Jack-up platforms is affected by the following factors: i) Oil price, ii)Utilization and day rate, iii) Technology, iv) New discovering, v) Fleet age, and vi) Fabrication Cost.

## DESIGNING OF JACK-UP PLATFORMS

### Design Parts of Jack-up Platforms

Jack-up platforms consist of three main parts that should be considered well in the design phase as follows:

#### *Design Elements (hull and legs)*

Jack-up platforms have box hulls that have a variety of shapes and heights, Jack-up platform hulls rest on a number of legs. The hull is used for accommodation, contains the required equipment to perform drilling and moving the Jack-up platform from one place to another. Legs of Jack-up platforms transfer the vertical and lateral loads to the foundation and then to the ground. The legs consist of a number of chords, extended throughout the length of the leg. The chords are tightened by bracing such as K, V, X and V inverted types. The legs can be lowered and raised by the mechanical system.

#### *Foundation*

Independent-leg spudcans or mats are the foundation types for Jack-up platforms. Legs are connected to a rigid plate structure that is mat. Mat foundation is used where the underneath

soil is leveled or when the soil is soft, but independent-leg spudcans are attached to the legs of the Jack-up independently so that it can be used in different levels of soil. They are designed in such a way to pass into the seabed and stabilize the platform to resist applied loads. Independent-leg Jack-up platforms are usually more expensive than mats since they are more applicable in a variety of places.

### *The Drilling Rig*

There are two types of drilling rig on Jack-up platforms, which are cantilevered and slot. A slot Jack-up platform places the drilling unit in the deck of the hull, and cantilevered Jack-up platform places the drilling on cantilevers that extended outward from the hull. Cantilevered designs are more suitable than slots since they enable to drill the oil wells on fixed platforms and closely spaced wells without repositioning rigs.

## Factors influencing the design of Jack-up platforms

The main factors affecting the design of Jack-up platforms are as follows:

### *Number of Legs*

Early Jack-up platforms were built with a large number of legs, sometimes more than ten legs. However, with the growth of technology, Jack-up platforms also were developed. Nowadays, the majority of Jack-up platforms have three legs that placed in each corner of the hull. The three-leg Jack-up platforms are mostly used in oil and gas industries, but there are other Jack-up platforms that have four legs and more, they are used in other fields of work.

Three-legged Jack-up platforms are more useful in comparison to four-legged units. Three-legged units are able to support more loads on the hull while floating than four leg units since three-legged unites have the less vertical weight of the legs and its associated Jacking system. Platforms that have three legs are cheaper since they use less steel for their fabrication. Moreover, the area subjected to environmental loads are less in the three-legged unites in comparison with the other platforms. On the other hand, the main advantage of the four-legged unites is greater stableness and a shorter time required to install the platform.

### *Leg's Length*

Water depth ability is the most important property of Jack-up platforms and affects its use and cost. Water depth capability is directly proportioned to the leg's length, which means if the water depth increases, the leg's length must be increased as well. The depth of water also has an impact on the volume of the hull. Since the water depth has such effect on the Jack-up platform design, it influences the cost of fabrication.

### *Conditions of Different Environments*

The environmental condition has an impact on the leg's length, hull volume, and leg's structure. For the Jack-up platforms expose to a harsh environment, a greater space between the sea level and the hull is required to let the water move freely below the hull. Simultaneously, the spacing between the platform's legs should be increased to gain a better stability of the platform in a harsh environment. In the harsh environments, the effect of wind and current loads can lead the change in the design consideration including the legs, hulls, and foundation.

### *Leg's type*

Jack-up platform's legs are classified into cylindrical legs and trussed legs that consisted a number of chords that tightened by the braces. Fabrication of the leg trusses are more expensive than the cylindrical legs, and they require a large number of welds to join braces to the chords. Despite that, the trussed legs have many advantages in comparison to cylindrical



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legs, the cylindrical legs are heavier than the trussed legs, so the steel cost is decreased for the trussed legs, and the trussed legs provide a better stability during the afloat case. The exposed area to the wind, current, and wave is reduced in the trussed legs, which reduces the high risk of loss during the storm. Early Jack-up platforms consisted of cylindrical legs. Nevertheless, later the Jack-up platforms developed to be used in deeper waters, so the trussed legs have become more common. Today all the platforms are fabricated with legs having trussed structures.

### *Chord Number and Type*

There are different ways to organize the leg's chords. The selection of the number and type of the chord is affected by the result of the structural analysis and the interaction between the leg of the platform and the Jacking system. Two main types of leg's chords are half round and teardrop chord.

### *Footing's Structure*

The legs of the Jack-up platforms are connected to a footing structure. The footing structures are either mat-like structure or independent spudcans. In both conditions, the aim of the foundation is to enlarge bearing area under the footing. Mat footing has dimensions approximately similar to the hull and they are box-like structures. Mat foundations have greater bearing area than independent spudcans and they are better than spudcans in soft seabeds. Nevertheless, Mat foundation cannot be used in sloping seabeds and near pipelines. By contrast, the spudcans are used on sloping seabeds and in different soil types. Spudcans are more popular especially when the depth of water is increased. Nowadays, the majority of footing structures are spudcans.

## STRUCTURAL ANALYSIS

Jack-up platforms are predominantly subjected to gravitational and environmental loads. The forces in the horizontal direction are mainly resulted from the environmental loads that cause shear and overturning moment. The forces in the vertical direction result from gravitational loads. The vertical and horizontal forces are transferred to the legs then to the spudcans, and finally to the ground. Jack-up platforms are subjected to different types of loadings that are shown in Fig. 2. Fig. 2. demonstrates a 2D representation of the gravitational, environmental, and the resulting foundation loads.

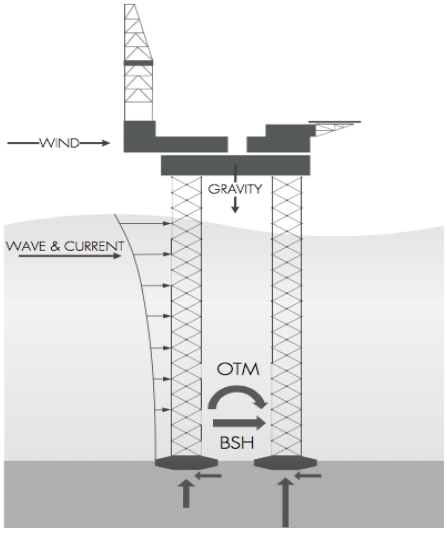


Fig. 2. 2D representation of gravitational, environmental, and the resulting foundation loads (Koole, 2015)

## MAIN ANALYSIS REQUIRED FOR JACK-UP PLATFORMS

The main analysis that should be performed to design Jack-up platforms are listed as follows:

i. In place analysis
ii. Earthquake analysis
iii. Impact analysis
iv. Temporary assembling analysis
v. Hydrodynamic analysis
vi. Transportation analysis
vii. Installation analysis

## FABRICATION PROCESS OF JACK-UP PLATFORMS

A wide leveled empty land beside shoreline, a number of cranes and a large enclosed space for carrying out proper welding are essential for the fabrication of Jack-up platforms. Transformation of materials, welding, plumbing, installation of machines, outfit materials and electrical work are main work activities in the fabrication of Jack-up platforms. Then the fabricated platform needs to be transferred to the waterway by launching system to reach its location.

The different parts of a Jack-up platform are fabricated as follows:

### Spudcans

Spudcans are made of hollow steel structures. Spudcans and hulls can be fabricated beside each other or they can be fabricated close to each other. After fabrication of the spudcans, they lifted into the hulls.

### Hull

The hull is fabricated from steel; a horizontal steel plate rests on secondary beams transferring the loads to the girders that are spaced 6 to 9 feet. 30- to 50-ksi steel is generally used to fabricate the hull, but some parts of the hull around the platform legs are manufactured from a high-grade steel to withstand the load.

### Topsides

After placing spudcans and hull, the jacking system and the topside including accommodation and offices are set up. The installation of other equipment, machinery, and outfitting work may be performed after or before putting the Jack-up in the water but it is more useful if performed before launching.

### Racks and Half-Rounds

Chord structures depend on the platform design, but the majority of them consist of three chords. A rack and half-rounds are welded together to form chords. Manufacturing of racks and half-rounds go through initial stages that transform high strength steel forms from steel mill into the half-rounds and racks.

In the early stage, racks are a solid plate and the plate is cut in order to form teeth shape. On the other hand, a flat plate of high strength steel is brought, and then a pressure is applied to it



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to form half-rounds. Later racks are welded to semicircular (half-rounds). Eventually, they are provided to the shipyard in order to be placed on the Jack-up platforms.

**Launching**

Jack-up platforms are fabricated beside the quays or in dry-docks. There are different ways for launching platforms; a slipway is used to launch the platforms into the water or several cranes are used to lift the platform so that the platform is walked into the water.

**Derrick and Cantilevers**

The derrick and cantilevers are built modularly and separately, then gathered together and set onto the hull, followed by launching the derrick that is generally fabricated by special firms in the shipyard and then transferred to be attached to the platform.

**Leg Assembly**

Before launching, in the early stage of fabrication, the spudcans and the jacking system are attached to the first section of the leg. After launching, the remaining sections of the leg are added by crane. They are added to the legs from the top or by using the lift capacity of the Jack-up platforms.

**Delivery and classification**

Jack-up platforms are offered to the buyer after final outfitting. The Jack-up platforms need to go through sea trials to get acceptance certification by the classification society. A set of guidelines are delivered for fabrication and design by classification societies so that the Jack-up platforms meet the requirements and could do their work properly.

## INSTALLATION

After fabrication of Jack-up platforms, Jack-up platforms are floated and moved toward the offshore drilling location on a hull with its legs elevated. Then, when it reaches its specified destination, the legs are lowered until the spudcans penetrate into the seabed. After that, the hull is stabilized by increasing the weight of it. By pumping the seawater into the ballast tanks placed in the hull, its vertical load is increased. The procedure of Jack-up platforms installation is illustrated in Fig. 3.

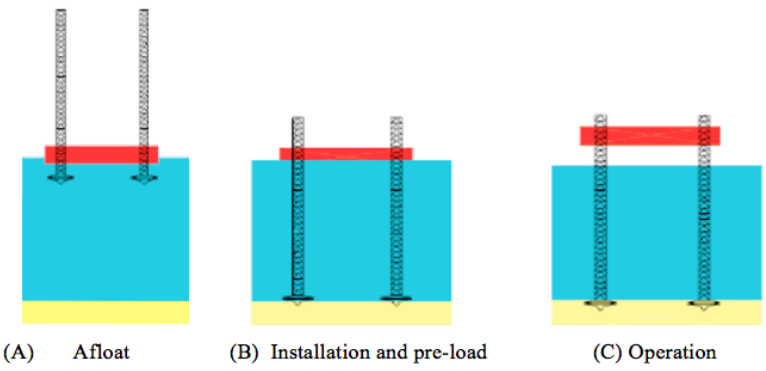


Fig. 3. Jack-up platform installation, preloading, and operation

For additional information on the environmental data together with necessary formulas and the data needed for design and analysis of such structures, the instructions, data and recommendations given by (Kaiser et al., 2013), (DNV Technical Report, 1996), (Jerman, 2015), (API, 2010), (Sadeghi, 1989, 2001, 2004, 2007a, 2007b, 2008 and 2013), (US Army Coastal Engineering Research Center, 1980), (US Army Corps of Engineers, 2002), Muyiwa and Sadeghi, 2007), (Sadeghi and Aleali, 2008) (Nouban and Sadeghi, 2013 and 2014), (US Army Corps of Engineers, 2011), (Nouban, 2016), (Nouban et al., 2016) and (Nouban et al., 2017) can be used.

## CONCLUSION

Jack-up platforms are selected primarily based on the deck equipment required to perform its service and the water depth consideration. Jack-up platforms may be used in water depth up to 500ft. When the depth of water is more than 500ft, another type of platform such as semisubmersible platform of drilling ship should be used.

Another important point is that the Jack-up platforms should be well floated and well installed because most of the failures of Jack-up platforms are due to their installation and floating processes.

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