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Analysis of Offshore Drilling's Vertical Load Using Semi-Submersible Rig

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ABSTRACT

In offshore drilling, requires an analysis of buoyancy which is owned by the rig. The magnitude of the platform's buoyancy was affected by the volume of total column which are submerged below sea level. The more volume columns submerged the more stable the platform rig stands. The buoyant force will hold two loads on the rig, the static load and dynamic load. Static load is the overall load of the rig, while the dynamic load is a load of the drillstring to be used in the drilling process. Maerks discoverers a semi-submersible rig with 4 columns and will conduct offshore drilling in the Gulf of Mexico. The planned target depth is 18,000 ft (True Vertical Depth), with drillpipe length for 12,000 ft and 6,000 ft drillcollar. With the formation pressure gradient of 0,465 psi/ft, the density of the mud is 10.54 ppg. Drilling is done with 4 drilling trajectory. It is also use ORQ mooring chain type with a diameter of 2 ¾ "by 4 units that have a tension load of 880 tons that can hold the submerged part so that a constant column during the drilling process that is as high as 15 m.

KEY WORDS: *Offshore drilling, Platform, Semi-Submersible Rig, Maersk Drilling*.

1.0 INTRODUCTION

At first, the operation of offshore drilling platforms is done by a large and costly 10 times greater if be compared to onshore drilling. With the development of technology and innovation to reduce the cost of drilling offshore, then there is one thing that is a major consideration for development which is mobility capabilities of the platform. This thing became the basis of the creation of a platform that can move on the sea and equipped with drilling equipment and rescue boats and even a place to stay for the crew working on the platform. A platforms should be able to move in any weather, it can be transformed from a position move to position drilling in a short time, resistant to high wind speeds and able to withstand the rigors of sea waves.

2.0 BASIC THEORY

2.1 Semi – Submersible Rig

Semi-submersible platforms generally consist of two boats at the bottom, used as ballast to stabilize the construction in the execution of drilling operations. Advantages of the semi-submersible platforms are have high stability. Because the center of gravity located below platform under the water that have a small lifting force of the waves (heave response). The smaller that fields submerged in water, then lift force of the waves will be smaller. Semi - Submersible can be carried out in deep water, and to keep in order to remain in place (the location of drilling), which can be implemented with the system of anchoring (mooring system) and a system of anchoring dynamic (dynamic position) or a combination of both systems , Anchorage system usually consists of eight anchors placed spread by following certain patterns. The anchor is connected to the ship by a chain or steel rope, even sometimes a combination of chains and steel ropes while the system anchoring the dynamic is a technique to keep the ship afloat in place without the use of anchors, but in this case the use of vectors generated of thrust force. (Chakrabarti Subrata, 2005), Criteria in selecting the semi-submersible platforms to consider some of the following:

1. Drilling Depth
2. Environmental Condition

3. Rig Moves Characteristic
4. Capacity
5. Mobility

There are three forces of influence and need to be accounted against offshore drilling, there are

1. Buoyancy
2. Static Load
3. Dynamic Load.

2.2 Buoyancy Factor

Based on Archimedes Law explained that the floating object moving mass of water weighing the object it self. Upward pressure as a result of a number of the displaced water is referred to as the lifting force or 'bouyancy'.

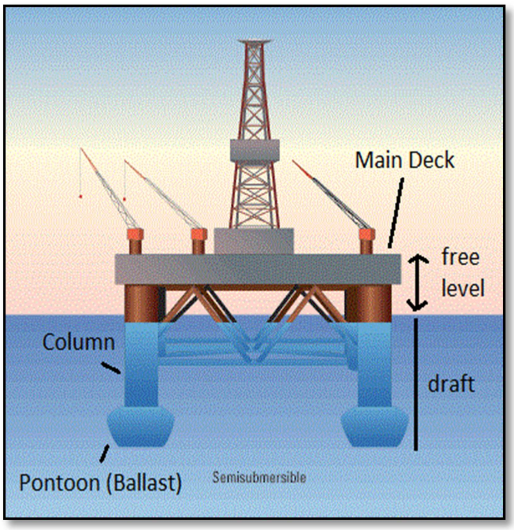

Figure 1: Buoyancy on Semi Submersible (Archimedes's Law)

Buoyancy is equal to the weight of the total volume of liquid displaced. Figure 1 shows that the column-shaped beam with 4 pieces plus 2 pieces of columns as a counterweight pontoon platform. The amount of lift (draft) on the drilling unit is the vertical distance measured from the water surface to the lowest part of the body of the unit. While the free surface level is the vertical distance measured from the waterline to the top of the unit body. Here is the equation of the buoyancy by Archimedes:

$$FA = \rho.g.v \qquad (1)$$

Annotation :

FA = *Archimedes Force = N*
P = *Liquid Density = Kg/M3*
g = *Gravity = N/Kg*
V = *Volume Submerged = m3*

Volume can be calculated in accordance with the shape we used, the semi-submersible uses pontoon and column in a block form, so the formula of volume is :

$$Volume = p \times l \times t \qquad (2)$$

Buoyancy is influenced by the ratio between the mass of objects and liquids.Density is a characteristic property of a substance.

The density of a substance is the relationship between the mass of the substance and how much space it takes up (volume). Here is the formula of Buoyancy Factor. (Chakrabarti Subrata, 2005):

$$Buoyancy = 1 – (\rho mud / 65.5) \qquad (3)$$

Annotation :

ρmud = *Mud Density, ppg*
65,5 = *Submerged steel density, ppg*

So, it is necessary to calculate the density of the mud that will be used during the drilling operation. The calculation of the density of the mud (Neal Adams, 1980) can be calculated by the formula:

$$\rho mud = Pf / (0.052 \times Depth) \qquad (4)$$

Annotation :

Pf = *Formation Pressure, psi*
0.52 = *Convertion to ppg*

2.3 Static Load

At drilling proccess, there are loads including dead load (fixed) for example rig, machinery and equipment, and dynamic loads such as drilling pipe, casing, Mud, cement, bit, BOP, fuel, water supply and ballast. It all must be considered carefully by all personnel involved. If the amount of fuel, for example, casing, or dynamic loads are stored on top of the drilling unit, the load of the equipment towards stability, draft and trim should be calculated.

a) Static load must be considered carefully by all personnel involved. If the amount of fuel, for example, the casing, or loads while stored on the drilling unit, the result of such goods to the stability, draft and trim should be calculated. In the deep sea drilling, BOP installed on the sea floor, so that the weight of the BOP (± 60 tonnes) and also casing when installed does not count because it is not retained by the platform.
b) Ballast is the weight of the pontoon which is located at the bottom of the platform. Usually consists of two pontoons by side. Ballast serves as a counterweight in the offshore drilling rig. Ballast weight must be greater than the static weight on the surface, this so that the platform remains in a vertical position. A minimum weight of ballast is 1.5x of heavy static on the surface. If the ballast weight is less than the weight on the surface of the platform will be reversed. If the ballast weight equal to the weight of equipment on the surface of the platform will be reversed in the horizontal position.

2.4 Dynamic Load

Dynamic loads on offshore drilling is divided into two, first dynamic loads caused by drilling operation and the second is dynamic loads caused by environment around the place. Dynamic load due to the environment such as the influence of waves, currents, and wind is considered already calculated in the planning of this drilling. Dynamic load due to the load of the

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drilling operation includes a series of drillstring itself, where the increasing depth of drilling, the more drill pipe used which have an impact on the increasing burden rig. Not only that other factors such as pipe wedged should also be noted therefore in the correlation calculations necessary safety factor. Dynamic load must be balanced with the buoyancy of the platform so that the platform was not shipwrecked, in other words there should be a limit on the depth of the drill can be achieved by a rig owned by the buoyancy. Drillstring consisting of drill pipe, drill collar, and bits. Length of drill pipe is usually 2/3 of the depth of drilling, while 1/3 is the drill collar.

2.5 BOP & Casing

After a drilling reaches a certain depth, then at that depth needs to be installed casing, which is then followed by cementing. Subsea BOP is usually installed after drilling has been through two series of drilling. The casing is a steel pipe which serves among other things: preventing avalanches walls of the well, close the abnormal pressure zone, the zone lost and so on. The main objective of the plan is to get the casing that is strong enough to protect the wells, both during drilling and production. There are 5 trajectory that is used on the drilling process, there are structural casing, conductor, surface, intermediate and production casing. Casing weight and the BOP are not included in the calculation of the dynamic load, because the casing was detained by the BOP and both is on the seafloor. The casing for drilling process in oil and gas industry has been standardized by the API (American Petroleum Institute), which has the following specifications:

1. Diameter
2. Pounder
3. Type of Connection
4. Grade
5. Range length

According to casing specification we can be choose the casing strength. In planning the specification there are three parameters used in determining the type of casing must be able to withstand a burst pressure, collapse, and the tension of the chassis itself. Burst load can be derived from wellhead pressure, hydrostatic pressure of the drilling mud and pressure at cementing. Other causes, all conditions that can cause the price of Pi (pressure from the fluid column inside the casing) is reduced by Pe (pressure from the fluid column outside the casing) is positive. Burst pressure is the minimum pressure (Pi - Pe) which can lead to rupture of the casing. Here is the formula calculating the load burst, (Neal Adams, 1980):

$$IYS = Pf \times Ni \quad (5)$$

Annotation :

IYS = *Internal Yield Strength Minimum, psi*
Pf = *Formation Pressure, psi*
Ni = *Safety factor for internal pressure*

Collapse load occurs when fluid pressure inside the casing (Pi) become smaller than the fluid that is outside the casing (Pe). This which will result in the casing be crushed. It is necessary for the calculation of load collapse (Neal Adams, 1980) using the formula:

$$Pc = 0{,}052 \times \rho m \times Z \times Nc \quad (6)$$

Annotation :

Pc = *collapse pressure, psi*
ρm = *Mud density, ppg*
Z = *Casing Depth, ft TVD*
Nc = *Safety factor for collapse pressure*

Tension load caused by the weight of casing itself. The heaviest tension load is on the surface, and tapers to zero, at a point on the series of casing. If the load exceeds the minimum strength casing, the casing will encounter a permanent deformation. Deformation will occur between the casing connection. Here is a tension load calculation formula (Neal Adams, 1980):

$$W = BN \times Z \times Bf \quad (7)$$

Annotation :

W = *Tension load, lb*
BN = *Casing pounder, lb/ft*
Z = *Casing depth, ft TVD*
BF = *buoyancy factor*

The stronger casing mean the price is more expensive. So the expensive price would lead to a well cost the most of it comes from the casing, not just that, casing and drillstring also need to count the total weight. So, when designing, the drillstring weight does not exceed the buoyancy of an offshore platform. It is necessary to design the casing to be lowered into the wellbore.

3.0 STUDY CASE

Drilling process will be carried out in the offshore zone. The platform will be deployed using the type Semi Submersible Drilling Platform by Maersk (MAERSK Discoverer). Maersk Discoverer has 4 columns, each column dimensions 17 m x 18 m x 30 m, and has two pontoon that each dimension of 115 m x 18 m x 10 m. For more details, the size of the semi-submersible rig used in the drilling can be seen in Figure 2.

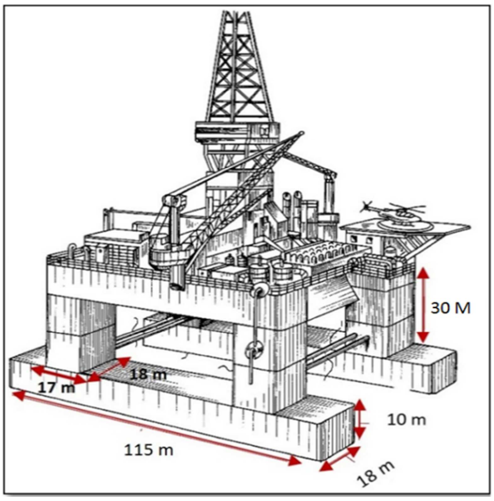

Figure 2: Semi Submersible (Friede & Goldman, Ltd.)

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For the main specifications of the platform used in this drilling can be seen in Table 1.

Tabel 1: Semi Submersible Main Particulars[11]

Main particulars

DIMENSIONS	IMPERIAL	METRIC
Length overall	384 ft	117 m
Width overall	256 ft	78 m
Length of pontoons	376 ft	115 m
Pontoon (width / height)	57 ft / 33 ft	18 m / 10 m
Columns	55 ft x 57 ft	17 m x 18 m
Upper hull (length / width)	259 ft / 258 ft	78.5 m / 78 m
Moonpool opening	108.3 ft x 29.5 ft	33 m x 9 m
Draft operational (max / min)	67.3 ft / 60.7 ft	20.5 m / 18.5 m
Draft transit	31.8 ft	9.7 m

PARTICULARS	IMPERIAL	METRIC
Rated drilling depth	40,000 ft	12,000 m
Hook load static (main)	2,500,000 lbs	1,134 t
Hook load static (aux)	1,500,000 lbs	680 t
Rotary load static (main)	2,756,000 lbs	1,250 t
Rotary load static (aux)	2,000,000 lbs	907 t
Setback load	2,646,000 lbs	1,200 t
Variable deck load (max / transit)	15,400,000 lbs / 10,120,000 lbs	7,000 t / 4,600 t
Variable column load (max / transit)	3,300,000 lbs / 880,000 lbs	1,500 / 400 t
Variable pontoon load (max / transit)	11,000,000 lbs / 4,400,000 lbs	5,000 t / 2,000 t
Total payload (max / transit)	29,900,000 lbs / 15,400,000 lbs	13,500 t / 7,000 t
Riser tensioner load	4,200,000 lbs	1,906 t
Pipe rack area	10,765 ft²	1,000 m²

The drilling program will be vertical wells at a total depth of 18,000 ft, where the drilling depth of 15,000 ft and 3,000 ft sea level. In this drilling using 5 trajectory which can be seen in Figure 3.

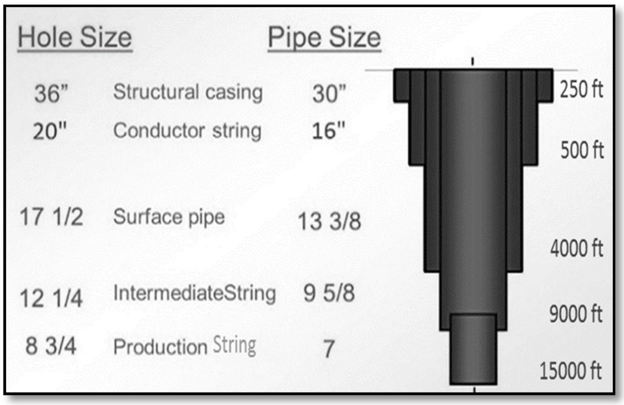

Figure 3: Profile Well

Structural casing mounted by mashed to the ground, while the conductor casing until the production is done drilling process. The following series of drillstring used for each trajectory of drilling can be seen in Figure 4.

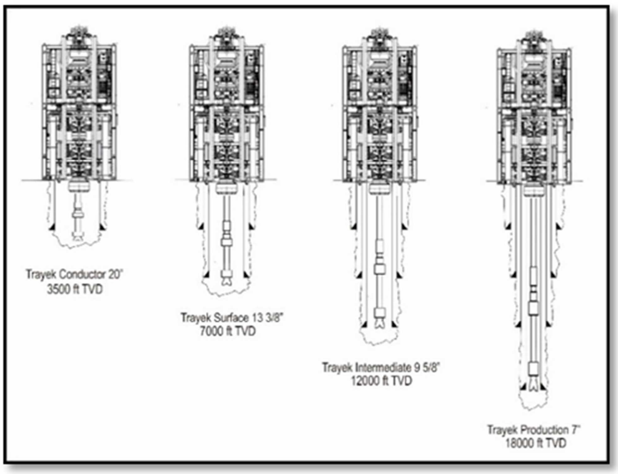

Figure 4: Drillstring Schematics

4.0 DISCUSSION

Buoyancy is a compressive force upward of the fluid towards an object that partially or completely immersed in the fluid. This happened due to the reaction of the fluid towards mass of the object that dipped into the fluid. The buoyancy of its own is the ability of an object that is on the fluid to float to its mass. This force is influenced by the ratio between the mass of the object with liquid. The mass of the object is obtained from the total mass of the object divided by the total volume. The buoyancy equal to the weight of water displaced. The size of the weight of an object is almost equal to the weight of water displaced.
An object wholly or partially sunk in a fluid would be get upward lift force equal to the weight of the fluid displaced fluid. The amount of the upward force by the Law of Archimedes was written in equation:

$$FA = \rho . g . V$$

Annotation:

FA = *Archimedes, N/M2*
ρ = *Fluid Density, Kg/M3*
g = *Gravity , N/Kg*
V = *Total Volume Sunken, M3*

4.1 Calculation of Semi Sub's Coloumn

1. Calculation of Semi Sub's Coloumn
   Volume Coloumn = (P x L x T) x 4
   = (17 x 18 x 30) x 4
   = 36720 m^3
2. Buoyancy (Semi-Submersible)
   Fa = V_{benda} x ρw x g
   = 36720 m^3 x 1028 Kg/m^3 x 9,81 N/Kg
   = 370.309.449,6 N

4.2 Calculation of Semi Submersible's Static Load

1. Volume Pontoon (*Ballast*)
   V pontoon = (115 x 18 x 10) x 2= 41400 m^3
   Pontoon volume according to the main specifications of

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semi-submersible rigs (Table III-1) Each pontoon accommodate a maximum of 5000 tonnes of sea water. So, the total of 10000 tonnes of ballast.

2. Platform's Static Loads (drilling equipment, person, safety, engine, drawwork, mast, etc) is 4600 ton
3. Platform's Static Loads + Volume Pontoon

F_{cg} = Massa x Gravity
= (Platform's Static Loads + Volume Pontoon) x Gravity
= 14600000 Kg x 9,81 N/Kg
= 143.226.000 N

From the results between gravity column with buoyancy force Floating Objects, the value of the gravitational force column is smaller than the buoyancy of objects (FCG <Fa) which means that the object will float.

4.3 Mud Density Calculation

In this mud density calculation in addition to knowing the pressure window also will be used to calculate the type of drillpipe to be used in the drilling process. To calculate the density of the mud especially need to know the value of the formation pressure as well as pressure fracturing the formation at each depth, formation pressure is used to calculate Rating BOP to be used on each route depth. In determining the formation pressure and pressure gradient required rekaf formation pressure all of which are interrelated and related.

The calculation of formation pressure and formation fracturing pressure at the deepest depth (production traject) is at a depth of 18,000 ft TVD.

Formation Gradient = 0.433 – 0.465 psi/ft
Fracture Gradient (Hubbert & Willis method)

$$Gr_f = \frac{1}{3}\left(1+2\frac{Pf}{Depth}\right)$$

Annotation:

Grf = 1/3 (1+ 2*(8370/18000)
= 0.643 psi / ft

Pf = Formation Gradient x Depth
= 0.465 x 18000
= 8370 psi

Prf = Fracture Gradient x Depth
= 0.643 x 18000
= 11574 psi

Based on the calculations above, in the same way, it can get a value formation pressure and formation fracturing pressure for each stretch of drilling can be seen in Table 2.

Table 2: Calculation of Formation Pressure and Fracture Pressure Formation

Depth (ft)	Formation Gradient (psi/ft)	Pf (psi)	Gradien Rekah Formasi (psi/ft)	Prf (psi)
7000	0.433	3031	0.622	4354
12000	0.455	5460	0.636	7632
18000	0.465	8370	0.643	11574

After obtained the value of formation pressure (Pf) and the formation fracturing pressure (Pr), it can be calculated density of the mud to be used on each route drilling. In this calculation used the calculation to find the density of the mud to stretch production at vertical depth of 18000 ft TVD, the following calculations:

Calculation of Mud Density @Production Traject 18000 ft

EMW Pf = Pf / (0.052 x Depth)
= (8370 + 200 psi) / (0.052 x 18000)
= 9.15 ppg

EMW Prf = Prf / (0.052 x Depth)
= (11574 – 400) / (0.052 x 18000)
= 11.93 ppg

EMW Design = (EMW Pf + EMW Prf) / 2
= (9.15 + 11.93) / 2
= 10.54 ppg

From the calculation, mud density values obtained at depths of 18,000 ft is 10,54 ppg.

4.4 Calculation of Semi-Sub's Dynamic Loads

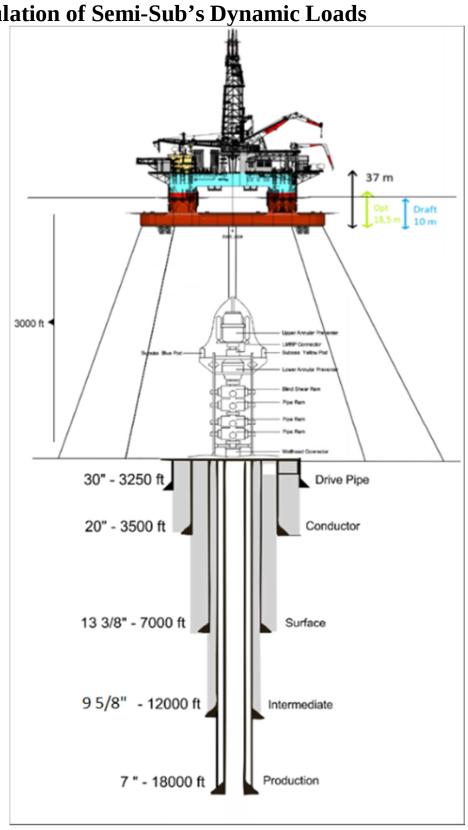

Figure 5: Well Construction[11]

In the design of this drilling, using Subsea BOP with riser system, wherein the dynamic load calculation Rig, which is the calculated weight of drillstring series current drilling operations take place. Drillstring size selected by 4 ½ "grade X-95 IEU, the determination based on the calculation collapse grade rating and

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also burst rating that has been calculated beforehand.

Calculation of Collapse Rating:

Pc = 0,052 x ρm x Z x Nc
Pc = 0.052 x 10.54 x 18000 x 1.125
= 11098,62 psi

Calculation of Burst Rating :

Pburst = Pf x Ni
Pburst = 8370 x 1.1
= 9207 psi

Calculation of Tension Rating:

W = BN x Z x Bf
W = 16.6 lb/ft x 18000 x ((65.5 – 10.54)/65.5)
= 250718.3 lb

Based on these data it can be seen casing collapse pressure of 11098 psi, burst pressure of 9207 psi, and the tension amounted to 250718.3 lb where Grade allowing it to withstand all the burden is on the X-95 grade IEU. Based on drillpipe Grade X-95 IEU then known weight of 16.6 lb / ft.

Calculation of Drillstring Weight at *Production Casing* (18000 ft TVD):

Drillpipe Weight = Panjang rangkaian x Nominal Weight
= 12000 x 16,6 lb/ft
= 199200 lb

Tool Joint Weight (DP) = Jumlah tool joint DPx Nominal Weight
= 400 x (1,41 ft x 19,19 lb/ft)
= 10847.14 lb

Drill Collar Weight = Panjang rangkaian DC x Nominal Weight
= (6000 / 30) x 2761
= 552200 lb

Tool Joint Weight (DC) = Jumlah tool joint DC x Nominal Weight
= 199 x (1,41 ft x 19,19 lb/ft)
= 5410 lb

Bit 8 ½" Weight = 130 lb

Total of Drillstring Weight = Drillpipe Weight + Drill Collar Weight + Bit Weight
= 767787.12 lb

Based on the calculations above, the total weight of drillstring at 18000 ft is 767787.12 lb, using the same formula it can be seen that the total weight of series in each trajectory of drilling can be seen in Table 3.

Table 3: Total Weight of Drillstring for Each Trajectory

Traject	Depth (ft)	DP Length (ft)	DC Length (ft)	Total Weight (lb)
Conductor	3500	2335	1165	150583.27
Surface	7000	4670	2330	299493.74
Intermediate	12000	8000	4000	512190.47
Production	18000	12000	6000	767787.12

The calculation in Table IV-2 is the weight of series in the air, due to the buoyancy factor it is necessary to use the buoyancy factor calculation formula Buoyancy:

Buoyancy = 1 – (ρmud / 65.5)

Annotation:

ρmud = Mud Density, ppg
65.5 = Steel Density

Total weight of drillstring in the air = 767787.12 lb

Total weight of drillstring with *Buoyancy Factor*
= Weight of Drillstring x BF
= 768004.61 lb x $\frac{65,5-10,54}{65,5}$
= 644237.87 lb

After knowing the total weight of the drillstring series in the air and when submerged in mud, then do dynamic load calculation.

Drillstring weight on BF * SF = 641958 x 1,2
= 770349,6 lb
= 350159 Kg

Dynamic Load = Drillstring Weight x Gravity
= 350159 Kg x 9,81 N/Kg
= 3.435.058,9 N

Total Reserve Buoyancy
= Semi-Sub Buoyancy – Semi-Sub Static Load
= 370.309.449,6 N – 143.226.000 N
= 227.083.449,6 N

From these results it can be seen how high the platform column for the Draft Transit:

Submerged Volume = 227.083.449,6 N / (1028 Kg/m^3 x 9,81 N/Kg)
= 22517 m^3

Draft Transit = $\frac{22517}{17 \times 18 \times 4}$
= 30 – 18 m
= 12 m

Maximum of Free Buoyancy Level on the rig Maersk Discoverer is 15 m. Therefore, in consideration of the stability of the rig operation where the greater volume of an object floating sink it will be increasingly stable, where the factors that influence the:

- Center of Gravity
- Center of Buoyancy
- Metacenter

So, it is necessary to design the mooring system that can withstand high platform on the optimal column, where the column height submerged optimal specifications of the platform is 15 m.

Buoyancy Optimum:
= Volume Coloumn Opt x Density Saltwater x Gravity x Amount of Coloumn
= (17x18x15) x 1028 Kg/m^3 x 9,81 N/Kg x 4
= 185154724,8 N

From the results of the calculation, optimum dynamic buoyancy forces that must be achieved by 185,154,724.8 N. While the buoyant force on a trajectory dynamic production of 146 661 059 N. A force of it then submerged column height of only 12 m, while the optimal amounts 15 m. It needs to be added

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(185,154,724.8 to 146,661,059) amounted to 38,493,666 N force to be optimum, the style can be added easily by filling the platform with sea water, the calculation is as follows:

Volume Opt = 38493666 N / (1028 Kg/m^3 x 9,81 N/Kg)
= 3817 m^3

or, as same as by adding sea water weighing:
= Volume Optimum x Density of sea water
= 3817 m^3 x 1,028 Ton/m^3
= 3924 ton

From the above results, excluding the effect of mooring force that secures the platform to remain stable. By using these types of Ramnäs Offshore mooring: type ORQ with a diameter of 2 3/4 "(Symmetric 4 Line) by sharing the load angle of 90 ° then the tension of mooring this type of:

Tabel 4: RamnäsMooring Spesification[2]

Test Load	Break Load					
Grade	ORQ	R3/ NVR3	R3S	R4	R4S	R5
C-factor	3060,3	3234,3	3611,4	3974,0	4409,1	4641,2
Inch						
2 3/4	889	940	1049	1154	1281	1348
2 13/16	927	979	1094	1203	1335	1406
2 7/8	965	1020	1139	1253	1391	1464
2 15/16	1004	1061	1185	1304	1447	1523
3	1044	1103	1232	1356	1504	1583

Tension Mooring = Break Load x 0,5
= 889 kip x 0,5
= 444.5 kip ≈ 202 ton

Total Weight which 4 mooring line can hold:
Total Weight = 202 ton x 4
= 808 ton

Tension Mooring = 808000 Kg x 9.81 N/Kg
= 7.926.480 N

From the calculation, obtained the power of the mooring line of 202 tons, using 4 pieces of mooring line then will be able to withstand the load of 808 tons. Load Break calculation is multiplied by 0.5 for the consideration of other styles that have not been included as the forces of wind, waves, currents, and waves.

After finding out the buoyancy of optimum height of the column is submerged at 15 m, also the tension on the mooring ORQ with a diameter of 2 ¾ ", then the next calculation of dynamic load each traject to see how the volume of water that must be added to each column in order to draft drilling fixed at a height of 15 m. Here is the calculation of each trajectory drilling:

4.4.1 Calculation of dynamic doad and filled coloumn volume at *conductor casing* (@3500 ft TVD)

Weight of drillstring on BF*SF
= 125869 x 1.2
= 151043 lbs
= 75521 Kg

Weight of Buoyancy:
= (Static Load + Dynamic Load + Tension Load) x 9.81 N/Kg
= (14600000 + 75521 + 808000) x 9.81 N/Kg
= 151.893.341 N

ΔF = Buoyancy Optimum – Buoyancy @Conductor
= 185.154.724,8 N – 151.893.341 N
= 33261383 N

Volume Coloumn = (33261383 N / (1028 Kg/m^3 x 9,81 N/Kg)) x Gravity Water
= 3298,2 m^3 x 1.028 Ton/m^3
= 3390 ton

4.4.2 Calculation of dynamic doad and filled coloumn volume at *surface casing* (@7000 ft TVD)

Weight of drillstring on BF*SF
= 250340 x 1.2
= 300408 lbs
= 150204 Kg

Weight of Buoyancy :
= (Static Load + Dynamic Load + Tension Load) x 9.81 N/Kg
= (14600000 + 150204 + 808000) x 9.81 N/Kg
= 152.625.981 N

ΔF = Buoyancy Optimum – Buoyancy @Surface
= 185.154.724,8 N – 152.625.981 N
= 32528742 N

Volume Coloumn = (33854859 N / (1028 Kg/m^3 x 9,81 N/Kg)) x Gravity Water
= 3225 m^3 x 1.028 Ton/ m^3
= 3315 ton

4.4.3 Calculation of dynamic doad and filled coloumn volume at *intermediate casing* (@12000 ft TVD)

Weight of drillstring on BF*SF
= 428128 x 1.2
= 513753,6 lbs
= 256876,8 Kg

Weight of Buoyancy:
= (Static Load + Dynamic Load + Tension Load) x 9.81 N/Kg
= (14600000 + 256876,8 + 808000) x 9.81 N/Kg
= 153.672.441,4 N

ΔF = Buoyancy Optimum – Buoyancy @Conductor
= 185.154.724,8 N – 153.672.441,4 N
= 31482283,4 N

Volume Coloumn = (31482283 N / (1028 Kg/m^3 x 9,81 N/Kg)) x Gravity Water
= 3121,8 m^3 x 1.028 Ton/ m^3
= 3209 ton

4.4.4 Calculation of dynamic doad and filled coloumn volume at *production casing* (@18000 ft TVD)

Weight of drillstring on BF*SF
= 641958 x 1.2
= 770349,6 lbs
= 350159 Kg

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Weight of Buoyancy
= (Static Load + Dynamic Load + Tension Load) x 9.81 N/Kg
= (14600000 + 350159 + 808000) x 9.81 N/Kg
= 154.587.539,8 N

ΔF = Buoyancy Optimum – Buoyancy @Conductor
= 185.154.724,8 N – 154.587.539,8 N
= 30567185 N

Volume Coloumn = (30567185 N / (1028 Kg/m^3 x 9,81 N/Kg)) x Gravity Water
= 3031 m^3 x 1.028 Ton/ m^3
= 3116 ton

From the dynamic load calculation on each traject of drilling, the volume can be obtained in the required fields so that high-level draft drilling does not change, also in order to keep the mooring tension and does not drop out. Here is a summary of drilling operations that can be seen in Table 5.

Tabel 5: Drilling Weight Indicator for Each Trajectory

Route			Circuit Weight (DP+DC+BHA)		Column Volume Filled
Type	Bit Size	Casing Size	Air	BF	
Conductor	26”	20”	150538 lb	125869 lb	3390 ton
Surface	17 ½”	13 3/8”	299493 lb	250340 lb	3315 ton
Intermediate	12 ¼”	9 5/8”	512190 lb	428128 lb	3208 ton
Production	8 ½”	7”	768004 lb	641958 lb	3116 ton

Then, we can calculate the weight of the total buoyancy that occurs in the deepest drilling trajectory is on a production traject with a depth of 18000 ft TVD, which amounted to:
Weight of Buoyancy
= (Drillstring Weight + Tension Load + Filled Coloumn) / (Number of columns)
= (14950 ton + 880 ton + 3116 ton) / 4
= 4736,5 ton

5.0 CONCLUSSION

So from calculations that have been done, with the safety considerations of various kinds of calculations have been done (addition / subtraction) calculation of the safety factor. Value Style Floating platforms amounted to 333,278,504.6 N. With a dynamic style pavilion total value amounted to 146 661 059 N, where the value of dynamic style drilling is smaller than the buoyancy of the platform, then the platform will not sink during drilling operations to a depth 18000 ft TVD. Dynamic buoyancy forces pavilion at 185,154,724.8 N, obtained from the calculation of the optimum volume of the platform column to be achieved is with dimensions p x l x t of 17 x 18 x 15 m multiplied by the force of gravity. The column height submerged in drilling trajectory production amounted to 15 m, as well as on each route drilling. Since it is very dangerous if the height of the column submerged change, because it will cause problems such as rupture mooring, to a series of drill pipe rupture due to fatigue heave compensator. Therefore, to make the column height submerged fixed at a height of 15 m, then the charging / reduction of fluid was added to the platform column. Stretch Conductor on the weight of water was added to 4 pieces of columns by 3390 tonnes, on the surface stretch as much as 3315 tons, the intermediate stretch of 3208 tons, and the production of 3116 tons trajectory. That way drilling process will be more stable and efficient. Free Buoyancy Level during ongoing drilling is 15 m. This is to prevent waves and currents that sometimes come.

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