Planning of Casing Design in AOV-1 Well Drilling, ANTARIS Field KSO-Pertamina EP – Banyubang Blora Energi (BBE)

Nur Suhascaryo¹, Bambang Ariyanto²

¹Petroleum Engineering Department, Faculty of Mineral, UPN “Veteran

Email of Corresponding Author:

bambangariyanto007@gmail.com

ABSTRACT

The AOV-1 well is a development well that is planned to be drilled in the “ANTARIS” Field. Based on the data obtained from the nearest well of “AOV-1” well, a casing design will be carried out, therefore it is necessary to select casing specifications. So that it can meet the requirements technically and economically.

Casing design planning is the preparation of file collected from drilling prognosis, and daily drilling report so that it can be used for calculation of pressure parameters, knowing stratigraphy, lithology, subsurface data, availability of casing stock in warehouse, and planning technical calculations for casing design operations such as d-exponent calculation to determine pore pressure, pressure calculation (formation pressure, overburden pressure, fracture pressure), calculation of the load received by casing (burst load, burst load design, collapse design), determination of casing setting depth, casing grade selection for casing design, calculation of biaxial stress correction of tension and compression stress, calculation of safety factor, and finally, calculation of economics from planning casing design.

7 ” casing program grade K-55, 20 PPF, BTC at a depth of 0 - 1968.5 ft TVD with safety factor Ni = 3.83 each; Nc = 2.19; Nj = 13.54, only 1 section is performed. casing program 9/8 " Casing program with grade K-55, 36 PPF, BTC at a depth of 0 - 820 ft. TVD with a safety factor of each Ni = 9.91; Nc = 4.83; Nj = 30.06, only 1 section is performed. 13 3/8 " casing program with grade K-55, 54.5 PPF, BTC at a depth of 0 - 250 ft. TVD with a safety factor of each Ni = 63.77; Nc = 22.99; Nj = 226.73, only done 1. The total cost for casing planning is $ 57,689 or around Rp. 816,876,240 of the budget provided, which is $ 65,000 or around Rp. 920,400,000.

Keywords: Casing, Casing Setting Depth, Casing Design, Burst, Collapse, Tension, Casing Grade Selection Economic

INTRODUCTION

After the drilling process reaches the targeted depth, the next step is the casing installation program. The installation of the casing aims to prevent many problems, including the collapse of the drill hole, lost circulation and closing the formation where the formation has abnormal pressure. The grade that the casing will use depends on the depth, formation pressure, formation fracture pressure, and lithology.

Well AOV-1 Field "ANTARIS" owned by KSO Pertamina EP - Banyubang Blora Energi is a development well and the data can still be obtained from the offset well as a sample for calculation. This well penetrates six formations, namely the Lidah formation, Mundu formation, Ledok formation, Wonocolo formation, Bulu formation, and Tawun Ngrayong formation.

The planning process for casing setting depth and casing design on Wells AOV-1. Technically, the casing must be safe, which is able to withstand the loads that will be received on the casing including external pressure, internal pressure and tension load because if the planning is not correct it can cause the casing to break or explode, besides it can cause the casing to break or explode, improper planning can also causing the casing to experience permanent deformation because the tension load on the casing exceeds the minimum yield strength, economically it should be as minimal as possible.

Determination of the casing setting
depth includes the estimation of well characteristics (well trajectory, pressure, stratigraphy, lithology, etc.), casing design planning (burst load, burst load design, collapse load, collapse load design, casing grade selection, biaxial stress), and economic results, casing design planning.

Location wells which used research on the thesis of this is well "AOV-1" "ANTARIS" Fields. Lapangan "Antaris" included in the area of work KSO Pertamina EP – Banyubang Blora Energy which is in the village of Bangoan District of Jiken Regency Blora.

METHODOLOGY

The methodology in planning the casing design for the well "AOV-1" Field "ANTARIS" includes:

1. Collecting field data that will be needed, such as drilling prognosis, daily drilling report, stratigraphic (formation & lithology), pressure parameters, and stock casing availability data in the warehouse.

2. Planning the operational technical calculations for casing design planning:
   a. D-exponent calculation to determine Pore Pressure.
   b. Calculations to determine overburden pressure and fracture pressure.
   c. Burst load calculation, burst load design, collapse load, collapse load design.
   d. Determination of the casing setting depth.
   e. Casing grade selections for casing design.
   f. Calculation of biaxial stress correction of tension and compression stress.
   g. Economies in casing design planning.

The following flowchart which can be used to make it easier to understand the methodology that is used in Figure 1.

Filed Geology Overview

Geological location of the "ANTARIS" field is in the Rembang zone, North East Java Basin (Van Bemmelen, 1949). The "ANTARIS" field is located on the anticlinorium hills that extend from West-East.

Figure 3. Physiography of the Rembang Zone
(Husein et al, 2019)
Well Geology Overview

Based on seismic interpretation, the position of the well "AOV-1" is at the top of the LA layer which is the structural layer of West Banyubang. The LA layer is the target reservoir for oil production, as well as in the entire Banyubang “AOV-1” Well Site Structure (both West Structure and East Structure). Based on the previous report, the results of the Layer Content Test (UKL), the L1 layer produced 346 BOPD, 0.03 MMCFD, and 7 BWPD oil. The other part is in the LC layer which is the oil-producing layer of the East Structure with the Wonocolo Formation carbonate sandstone reservoir. Whereas in the West Structure, the LC layer carried out by UKL at Well 1 is in a different compartment from the West Structure.

Filed General Stratigraphy

In general, Stratigraphy "Antaris" Fields entry into the zone of Rembang follow the scheme prepared by Pringgoprawiro (1983) can be seen in Figure 4. Based on the data below the surface of the exploration of hydrocarbons in the region is, units of the stratigraphy of the oldest at the top of the rock base is the formation Kunjung. However, the formation is not exposed on the surface, at the Well AOV-1 Field antaris the target formation is the formation Ngrayong. (stratigraphic column)

| No | Formation | h  | Depth |
|----|-----------|----|-------|
| 1  | Lidah     | 130| 0     | 130   |
| 2  | Mundu     | 160| 130   | 290   |
| 3  | Ledok     | 110| 290   | 400   |
| 4  | Wonocolo  | 130| 400   | 530   |
| 5  | Bulu      | 50 | 530   | 580   |
| 6  | Tawun & Ngrayong | 150| 580 | 730   |
| 7  | Tuban     | 185| 730   | 915   |
| 8  | Prupuh    | 85 | 915   | 1000  |
| 9  | Kunjung   | 200| 1000  | 1200  |

Well Geological Structure "AOV-1"

The reference layer in the West Banyubang structure is the LA and LB layers which are the targets of the well "AOV-1", where the layers are oil-producing reservoirs inwells 1 and 3. Whereas in well 4 which is 50 meters from well 1, Layer L1 with a depth down a 7 meter dip filled with water. So it is interpreted that the positions of wells 4 and 1 are close to the WOC. This can also be seen on the depth structure map where the positions of wells 1, 3 and 4 are in the down dip of the west structure anticline.

Figure 4. Stratigraphic Column of Blora and Surrounding Areas (Harsono Pringgoprawiro, 1983)

Figure 5. Seismic Section 87-CPU-15; North-South (from left-right) The structure of West Banyubang (PT. Banyubang Blora Energi, 2019)
Well Data

Determination of Casing Setting Depth

The first plan in well design is the selection of the depth at which the casing is run and cemented. Drilling engineers in depth casing setting planning must consider geological conditions, such as: formation pressure and fracture gradient, hole problems, and other things.

Pressure Formation is the pressure that is caused by fluid in the formation.

Formation pressure can be said to be normal if it has a value of 0.433 psi / ft to 0.465 psi / ft. If the gradient value is less than 0.433 psi / ft, the formation pressure can be said to have subnormal pressure and if the gradient value is less than 0.465 psi / ft, the formation pressure can be said to have abnormal pressure. The equation that is often used to determine formation pressure is the d-exponent equation (Jordan and Shirley).

\[
d = \frac{\log (\frac{R}{MW})}{\log (1000 d_{\text{exponent}})}
\]

(1)

\[
d_{\text{exponent koreksi}} = \frac{9}{MW}
\]

(2)

Figure 6. East Java Basin Petroleum System (Harsono Pringgoprawiro, 1983)

Reservoir is an ngerayong formation. The petroleum system itself consists of source rock, pressure and temperature, migration, reservoir, caps rock, and reservoir trap.

Source Rock is a Feather Formation whose lithological characteristics are from the intersection of limestone with calcarenite, sometimes found inserts of clay rock.

Reservoir is an ngerayong formation characterized by the presence of fine-sized quartz sandstones at the bottom and tends to coarse at the top and sometimes limestone.

Caps Rock originates from the Tuban Formation because the formation consists of clay rock and sometimes there are inserts of limestone.

Migration itself is a process of oil and gas moving away from source rock. This process covers a great distance and takes a very long time. ft, the formation pressure can be said to have subnormal pressure and if the gradient value is less than 0.465 psi / ft, the formation pressure can be said to have abnormal pressure. The equation that is often used to determine formation pressure is the d-exponent equation (Jordan and Shirley).

Figure 7. D-Exponent Correction vs Depth ft TVD Chart
Formation Pressure

\[
EMW = \frac{-0.3}{dc}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)
\]

\[
Gf = 0.052 \times EMW \times D\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)
\]

EMW Pore Pressure

\[
EMW \ Pore \ Pressure = \frac{\text{Pore \ Pressure}}{0.052 \times \text{Depht}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)
\]

EMW Pore Pressure Margin

\[
EMW \ Pore \ Pressure \ Margin = EMW \ Pore \ Pressure + 0.5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)
\]

Hydrostatic Pressure

\[
Ph = 0.052 \times MW \times D\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)
\]

Overburden pressure is the pressure that is generated from the combined weight of the mixture of minerals that precipitated (matrix rock) coupled with the weight of the fluid (water, oil, gas) that fills the pores of rocks that.

Generally pressure of overburden will grow large with increasing depth. The normal overburden pressure gradient is 1 psi / ft (0.231 kg / cm² m). With regards heavy kind of rock an average of 2.3 of a severe type of water, while the magnitude of the gradient pressure of water is 0.433 psi / ft, so the magnitude of the gradient pressure of overburden is 2.3 x 0.433 psi / ft would be equal to 1.0 psi / ft.

Overburden Pressure

\[
Pob = \frac{0.052 \times pb \times 8.33 \times D - (0.052 \times (pb - pw) \times 8.33 \times \Phi_{top})}{\Phi_{bott} \times (1 - \exp(-\Phi_{bott} \times D))}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)
\]

In Figure 8. Shows the EMW pressure window plot between depth vs formation pressure gradient and depth vs formation fracture pressure gradient. In addition, the trip in margin line is also plotted where the value is 0.5 ppg greater than the formation pressure and the trip out margin line which is 0.5 ppg less than the formation fracture pressure.

This pressure gradient can be corrected by the provisions of the amount of pressure can be seen in Figure 7. that Ph > Pf < Prf < Pob.

Calculating EMW Fracture Pressure

\[
EMW \ Fracture \ Pressure = \frac{Fracture \ Pressure}{0.052 \times \text{Depht}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)
\]

Calculating EMW Pore Pressure Margin

\[
EMW \ Fracture \ Pressure \ Margin = EMW \ Fracture \ Pressure + 0.5\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)
\]

Fracturing pressure are pressure hydrostatic formation of the maximum that can be detained without causing the rupture. The magnitude of the fracture pressure gradient is influenced by the amount of overburden pressure, formation pressure and rock strength conditions. Because in fact the overburden pressure gradient is different at each depth.

Can be seen in Figure 9, are requisite conditions of pressure that must be met, namely Ph > Pf < Prf < Pob. If you look at the figure, the pressure has met the requirements, where to determine the casing setting depth you must pay attention to the pressure aspect where the pressure will be received by the casing.
Formation Fracturing Pressure

\[ Fr = \frac{P}{D} (P_{ob} - P_{fr}) (K) \] ............................................... (9)

Figure 9. Pressure Window Conditions

In this research, the approach method used for determining the casing setting depth is the bottom to top method, as shown in the figure 10.

Figure 10. Casing Setting Depth Bottom to Top
(Bourgoyne, Adam T. Jr, dkk., 1986.)

The process of determining the length of casing and casing point requires some data, including pressure fracture, pressure formation, lithology and correlation of wells and surrounding stratigraphy. Based on the results of the formation pressure data plot and formation fracture pressure in Figure 10, the depth of the casing settings is obtained from several casings.

Figure 11. Casing Setting Depth Wells
AOV-1

The process of determining casing setting depth in proceed with the selection of the size of the casing and the size of the holes drilled, the election it can use the chart elections Neil J. Adam crate on Figure 12.

Figure 12. Bit dan Case Size
(Adam, J. Neal. 1985.)
Table 2

| Trayek Sumur AOV | T | ole | D | Casing | ng | m | t | h | nch |
|------------------|---|-----|---|--------|----|---|---|---|-----|
|                  | m | ft  |   |        |    |   |   |   |     |
| Production       | 1/2 | 600 | 1968, 5 ft |
| Intermedi ate    | 1/4 | 5/8 | 820 ft |
| C onductor       | 1/2 | 3 3/8 | 98,42 |

The plot results are used in the process of determining the casing setting depth at Well AOV-1, where the results of the data plot are obtained 3 casing casings. In the calculation process, counting as many as 3 casings, because in this casing depth setting planning using the bottom to top method, the determination of the depth and calculations starting from the lowest casing can be seen in Table 2. where each casing are as follows:

- **Casing Design Planning**
  In this research, the approach method used for casing design planning is a graphical method, as shown in Figure 14 and Figure 15. The graphical method is used by calculating the load acting on the casing by plotting the pressure against the depth, resulting in burst lines, collapse lines, burst design lines, and collapse design lines. without assuming the worst burden.

- **Figure 14.** Selecting Casing Below Point C (Badu, Kaswir. 2007.)

- **Figure 15.** Selecting Casing Above Point C (Badu, Kaswir. 2007.)

**Burst Load**
- Burst pressure on the surface
  \[ \text{Pb @ surface (Pf)} = Gf \times D \] ........................................ (11)
- Burst pressure on casing shoe
  \[ \text{Pb @ shoe} = \text{Pb @ surface} - (D \times Gg) \] ......(12)
- Burst pressure design on the surface
  \[ \text{BPD @ surface/TOL} = \text{Pb @ surface/TOL} \times \text{Safety factor} \] .................................................. (13)
- Burst pressure design on casing shoe
  \[ \text{BPD @ shoe} = \text{Pb @ shoe} \times \text{Safety factor} \] ...(14)

Plot the Pb @ surface and Pb @ shoe value on the chart. The resulting line is Burst load line. And plot the BPD @ surface and BPD @ shoe prices on the graph that has been made. The resulting line is Burst load line design.

**Collapse Load**
- At zero depth or at the surface the
external pressure is zero, because the mud column height pressing the casing does not exist

\[ P_{c@\text{surface}} = 0 \] .................................................. (15)

- At the top off liner depth and due to hole deviation, the external pressure is:

\[ P_{c@TOL} = 0.052 \times \rho_m \times DTOL \] ............... (16)

- The Collapse Load on the casing shoe

\[ P_{c@\text{shoe}} = 0.052 \times \rho_m \times D \] .................... (17)

- Desain Design pressure Collapse on the surface

\[ CPD_{@\text{surface/TOL}} = P_{c@\text{surface/TOL}} \times \text{Safety factor} \] ........................................... (18)

- Collapse design pressure on the casing shoe

\[ CPD_{@\text{shoe}} = P_{c@\text{shoe}} \times \text{Safety factor} \] 

.................................... (19)

Plot of \( P_{c@\text{surface}} \) and \( P_{c@\text{shoe}} \) value on the chart. The resulting line is a Collapse load line. And plot the CPD @ surface and CPD @ shoe prices on the chart. The resulting line is a Collapse load line design

![Figure 16. Graph of Burs Load Line and Collapse Load Line Casing 7"](image)

Table 3.
Selection of Casing Grade on Casing 7"

| Interval | Grade | Collaps  | Interval | Joint | Pipe          |
|----------|-------|----------|----------|-------|---------------|
| ft TVD   | BN    | collapse | pressure | strength | body resistance | yield |
| 830-1684.5 | K-55  | 20 BTC   | 2270 psi | 3740 psi | 451000 lbs     | 316000 lbs |

In this research, the approach method used for casing design planning is a graphical method, as shown in Figure 14 and Figure 15. The graphical method is used by calculating the load acting on the casing by plotting the pressure against the depth, resulting in burst lines, collapse lines, burst design lines, and collapse design lines. Without assuming the worst burden.

![Figure 17. Graph of Burs Load Line and Collapse Load Line Casing 9 5/8"](image)
Table 4.
Selection of Casing Grade on Casing 9 5/8"

| Interval ft TVD | Grade BN | Coupling | Collapse resistance | Interval pressure resistance | Joint strength | Pipe body yield |
|----------------|----------|----------|----------------------|-------------------------------|---------------|----------------|
| 830-1968,5     | K-55     | 36       | BTC                  | 2020                          | 3520          | 755000         | 564000         |

Table 5
Selection of Casing Grade on Casing 13 3/8"

| Interval ft TVD | Grade BN | Coupling | Collapse resistance | Interval pressure resistance | Joint strength | Pipe body yield |
|----------------|----------|----------|----------------------|-------------------------------|---------------|----------------|
| 0-98,425       | K-55     | 36       | BTC                  | 1130                          | 2730          | 1038000        | 853000         |

**Tension Load**
- **Bouyancy factor**
  \[ BF = 1 - \left(\frac{\rho_m}{65.5}\right) \] .......................... (20)
- **Case weight in air, lbs**
  \[ Wa = Ls \times BN \] ................................................. (21)
- **Case weight in mud, lbs**
  \[ W_m (Tension load) = Ls \times BN \times BF \] ........... (22)
- **Casing weight in mud due to hole deviation, lbs**
  \[ W_m (Tension load) = Ls \times BN \times BF \times \cos \alpha \] ....(23)
- **Cross-sectional area of the casing, in2**

**Joint Strength**
- **Maximum weight the case can hold, lbs**
  \[ W_{max} = \frac{F_j}{S_f} \] ..............................................(25)
- **Maximum weight the casing can hold due to hole deviation, lbs**
  \[ W_{max} = \left(\frac{F_j \times \cos \alpha}{S_f}\right) \] .................(26)
- **The maximum length the case can hold, ft**
  \[ L_{max} = \frac{W_{max}}{BN} \] ..............................................(27)
- **The maximum length the casing can hold due to the casing ft combination, ft**
  \[ L_{max} = W_{max} - \text{Tension load total}/ BN \] ...........(28)

**Biaxial Stress**
- **Axial load factor**
  \[ X = \left(\frac{\text{Beban Tension / Pipe body yield strength}}{}\right) \] ......(29)
  Entering the price of X to the graph baxial stress in Figure 3.12 or already available in Table 6, so it gained the price factor of collapse strength.
  **Collapse resistance and Burst resistance corrected to tension loads can be determined by the following equation:**
  \[ CRC = (Y) \times MCR \] ..............................................(30)
Table 6

| X (y) | y  | x   | y   | x   | y   | x   | Y   | x   | y   |
|-------|----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0.005 | 0.999 | 0.205 | 0.927 | 0.405 | 0.815 | 0.65 | 0.654 | 0.805 | 0.42 |
| 0.010 | 0.997 | 0.21  | 0.925 | 0.41  | 0.812 | 0.7  | 0.65  | 0.81  | 0.412 |
| 0.015 | 0.996 | 0.215 | 0.922 | 0.415 | 0.808 | 0.75  | 0.645 | 0.815 | 0.405 |
| 0.020 | 0.995 | 0.22  | 0.92  | 0.42  | 0.805 | 0.8   | 0.64  | 0.82  | 0.398 |
| 0.025 | 0.993 | 0.225 | 0.918 | 0.425 | 0.801 | 0.85  | 0.635 | 0.825 | 0.39 |
| 0.030 | 0.992 | 0.23  | 0.915 | 0.43  | 0.798 | 0.9   | 0.63  | 0.83  | 0.382 |
| 0.035 | 0.99  | 0.235 | 0.913 | 0.435 | 0.794 | 0.95  | 0.625 | 0.835 | 0.374 |
| 0.040 | 0.989 | 0.24  | 0.91  | 0.44  | 0.791 | 1     | 0.62  | 0.84  | 0.366 |
| 0.045 | 0.987 | 0.245 | 0.908 | 0.445 | 0.787 | 1.05  | 0.615 | 0.845 | 0.358 |
| 0.050 | 0.986 | 0.25  | 0.905 | 0.45  | 0.784 | 1.1   | 0.609 | 0.85  | 0.35 |
| 0.055 | 0.984 | 0.255 | 0.903 | 0.455 | 0.787 | 1.15  | 0.604 | 0.855 | 0.342 |
| 0.060 | 0.983 | 0.26  | 0.9   | 0.46  | 0.776 | 1.2   | 0.599 | 0.86  | 0.334 |
| 0.065 | 0.981 | 0.265 | 0.898 | 0.465 | 0.773 | 1.25  | 0.594 | 0.865 | 0.325 |
| 0.070 | 0.98  | 0.27  | 0.895 | 0.47  | 0.769 | 1.3   | 0.588 | 0.87  | 0.316 |
| 0.075 | 0.978 | 0.275 | 0.893 | 0.475 | 0.765 | 1.35  | 0.583 | 0.875 | 0.307 |
| 0.080 | 0.976 | 0.28  | 0.89  | 0.48  | 0.761 | 1.4   | 0.577 | 0.88  | 0.298 |
| 0.085 | 0.975 | 0.285 | 0.887 | 0.485 | 0.757 | 1.45  | 0.572 | 0.885 | 0.289 |
| 0.090 | 0.973 | 0.29  | 0.885 | 0.49  | 0.754 | 1.5   | 0.566 | 0.89  | 0.28 |
| 0.095 | 0.971 | 0.295 | 0.882 | 0.495 | 0.75  | 1.55  | 0.561 | 0.895 | 0.27 |
| 0.100 | 0.969 | 0.3   | 0.879 | 0.5   | 0.746 | 1.6   | 0.555 | 0.9   | 0.261 |
| 0.105 | 0.968 | 0.305 | 0.876 | 0.505 | 0.742 | 1.65  | 0.549 | 0.905 | 0.251 |
| 0.110 | 0.966 | 0.31  | 0.874 | 0.51  | 0.738 | 1.7   | 0.543 | 0.91  | 0.241 |
| 0.115 | 0.964 | 0.315 | 0.871 | 0.515 | 0.734 | 1.75  | 0.538 | 0.915 | 0.23 |
| 0.120 | 0.962 | 0.32  | 0.868 | 0.52  | 0.73  | 1.8   | 0.532 | 0.92  | 0.22 |
| 0.125 | 0.96  | 0.325 | 0.865 | 0.525 | 0.725 | 1.85  | 0.526 | 0.925 | 0.209 |
| 0.130 | 0.958 | 0.33  | 0.862 | 0.53  | 0.721 | 1.9   | 0.52  | 0.93  | 0.198 |
| 0.135 | 0.956 | 0.335 | 0.859 | 0.535 | 0.717 | 1.95  | 0.513 | 0.935 | 0.187 |
| 0.140 | 0.954 | 0.34  | 0.856 | 0.54  | 0.713 | 2     | 0.507 | 0.94  | 0.175 |
| 0.145 | 0.952 | 0.345 | 0.853 | 0.545 | 0.709 | 2.05  | 0.501 | 0.945 | 0.163 |
| 0.150 | 0.95  | 0.35  | 0.85  | 0.55  | 0.704 | 2.1   | 0.495 | 0.95  | 0.151 |
| 0.155 | 0.948 | 0.355 | 0.847 | 0.555 | 0.7    | 2.15  | 0.488 | 0.955 | 0.139 |
| 0.160 | 0.946 | 0.36  | 0.844 | 0.56  | 0.696 | 2.2   | 0.482 | 0.96  | 0.126 |
| 0.165 | 0.944 | 0.365 | 0.841 | 0.565 | 0.691 | 2.25  | 0.475 | 0.965 | 0.112 |
| 0.170 | 0.942 | 0.37  | 0.838 | 0.57  | 0.687 | 2.3   | 0.469 | 0.97  | 0.098 |
| 0.175 | 0.94 | 0.375 | 0.835 | 0.575 | 0.682 | 2.35  | 0.462 | 0.975 | 0.084 |
| 0.180 | 0.938 | 0.38  | 0.831 | 0.58  | 0.678 | 2.4   | 0.455 | 0.98  | 0.069 |
| 0.185 | 0.936 | 0.385 | 0.828 | 0.585 | 0.673 | 2.45  | 0.448 | 0.985 | 0.053 |
| 0.190 | 0.934 | 0.39  | 0.825 | 0.59  | 0.668 | 2.5   | 0.441 | 0.99  | 0.036 |
| 0.195 | 0.931 | 0.395 | 0.822 | 0.595 | 0.664 | 2.55  | 0.434 | 0.995 | 0.019 |
To determine the safety factor for each force is the equation:

\[
\text{SF}_{Ni} = \frac{\text{Internal Pressure Resistance}}{\text{Collapse Resistance}} \quad \text{.........(31)}
\]

\[
\text{SF}_{Nc} = \frac{\text{Collapse Resistance}}{\text{Joint Strength}} \quad \text{.........(32)}
\]

\[
\text{SF}_{Nj} = \frac{\text{Joint Strength}}{\text{Burst Pressure}} \quad \text{.........(33)}
\]

**Beban Tension**

\[
\text{Beban Tension} = \text{HC} \times \text{Lc} \quad \text{.............(34)}
\]

**Table 8. Safety Factor**

(Bourgoyn, Adam T. Jr, dkk. 1986.)

|      | Collapse (Nj) | Tension (Nj) | 1.25 | 0.7  | 1   |
|------|---------------|--------------|------|------|-----|
|      | 2             | 1.6          | 1.8  |      |     |

To determine the safety factor for each force is the equation:

\[
\text{SF}_{Ni} = \frac{\text{Internal Pressure Resistance}}{\text{Collapse Resistance}} \quad \text{.........(31)}
\]

\[
\text{SF}_{Nc} = \frac{\text{Collapse Resistance}}{\text{Joint Strength}} \quad \text{.........(32)}
\]

\[
\text{SF}_{Nj} = \frac{\text{Joint Strength}}{\text{Burst Pressure}} \quad \text{.........(33)}
\]

**Table 9. Safety Factor of Each Load**

| Trayek | Ni     | Nc     | Nj     |
|--------|--------|--------|--------|
| 7"     | 3.83   | 2.19   | 13.54  |
| 9 5/8" | 9.91   | 4.83   | 30.06  |
| 13 3/8"| 63.77  | 22.99  | 226.73 |

**Casing Fee**

\[
\text{TB} = \text{HC} \times \text{Lc} \quad \text{.............(34)}
\]

In planning casing also consider aspects of the economy where the grade that has been corresponding requirement is technically required the calculation of the cost of the case in accordance with the prices and supplies are there. Calculation details of the price and the cost of the casing in wells AOV-1 Field Antaris, where the price of casing $ / joint drawn from the data drilling program wells AOV-1.

The total cost of the price of casing $ / joint production 7 "K-55; 20 pff ; BT; R3 48 ft at Well AOV-1 Intermediate Field for production casing 7 " with a depth of 1968.5 ft TVD

\[
\text{TB} = \text{HC} \times \text{Lc} \quad = 757 \$/\text{joint } \times 41 \text{ joint (1968.5 ft)} \quad \text{R3 48 ft}
\]

\[
= 31,037 \quad \text{in Rp} \quad = 439,483,920
\]

\[
\text{The total cost of the price of casing $ / joint production 9 5/8 "K-55; 36 pff ; BT; R3 45 ft at Well AOV-1 Intermediate Field production casing 9 5/8 " with a depth of 820 ft TVD}
\]
.TB  = HC x Lc
     = 1294 $/joint x 18 joint (820 ft)
     = R3 45 ft
     = $ 23,292

in  Rp  = $ 23,292 x 14160

Rp  = 329,814.720

The total cost of the price of casing $ / joint production 13 3/8 "K-55; 54.5 ppf ; BT; R3 45 ft at Well AOV-1 Intermediate Field production casing 13 3/8 “with a depth of 98,425 ft TVD.

TB  = HC x Lc
     = 1680 $/joint x 2 joint (98,425 ft)
     = R3 45 ft
     = $ 3.360

in  Rp  = $ 3.360 x 14160

Rp  = 47,577.600

From the results of the calculation of the price of casing corresponding grade who have obtained a total cost in each trayeknya , as follows:

1. The production casing gets a total cost of $31,037 or around Rp. 439,483,920
2. Intermediate casings get a total cost of $23,292 or around Rp. 329,814,720
3. The conductor casing gets a total cost of $3,360 or around Rp. 47,577,600

So, for the total cost of the whole of elections grade casing for planning the design of the casing is $ 57,689 or approximately USD 816,876 240.

RESULT AND DISCUSSION

In a process of drilling wells of oil and gas earth for the well development , should no guidelines for carrying out the process of planning it , where the guidelines that can be obtained from wells previously , could also get out of the well closest because they will be there a few factors that must be considered among the factors geology , where the factors of geology encompasses many aspects of which aspects of the stratigraphic layers of a region, area or field it , so it can analyze formations and layers of what course that will penetrate the drilling of stratigraphic that , besides the know lithologic what course are contained in the formation of a layer-lasian that , because of the structure of the formation of each region, the region and even the pitch can vary so that in doing correlation to it , to know where the location of the formation of a layer of productive and prospects that will be used as the target of the usual so-called reservoir. The ultimate goal of the well planning process is to facilitate drilling operations where the drilling operation can be completed in a short , safe , efficient and economical operational time in accordance with drilling and production planning.

In the process of casing planning terms of most major before determining casing setting depth is to calculate the parameters required for the process of casing setting depth that the parameters of pressure , there are several parameters of pressure that must be calculated that formation pressure, hydrostatic pressure, overburden pressure and fracture pressure. There are requirements that must be met on all parameters of the pressure that is diamana hydrostatic pressure should be great bit of formation pressure, because if the hydrostatic pressure is smaller than formation pressure can lead to problems kick, hydrostatic pressure also should be smaller than the fracture pressure, because if the hydrostatic pressure more large of fracture pressure will lead to the problem of lost circulation, and fracture pressure is smaller than the overburden pressure. If the parameters of the pressure that already meet the rule requirements that apply can be said to suit the requirements and can proceed to the process of casing setting depth planning. Casing setting depth planning can be done by two ways , namely by way top to bottom or bottom to top, the way these but used with regard graph of pressure which in the plot that is the pressure formation and pressure fracturing , the thesis is a graph setting depth using Equivocal Mud Weight of pore pressure and fracture pressure. In formations that have pressure window width , will be easy to do approach uses a bottom to top, and if done will get the amount of stretch that is slightly out of the top to bottom. If you have gone through the casing setting depth process so that you know the target depth of each casing , the next step is the casing design planning process.

Casing Planning generally there are two factors that influence is a factor of technical and economic. Will however , Fator technically is a factor that is more preferred than the factor of the economy because if the design of the casing of a well better take into account the factor of economics are more cost sometimes of in terms of technically less meet the requirements and criteria of a safe that will cause problems in later days. There are 3 methods of planning the casing design , namely the graphic method , the maximum load and the analytical method. In the thesis is the method that is used is the method of
the graphics, which is a method based on the loads that work on the
chassis, by plotting pressure against depth. With steps do the
calculations for the parameters of burst load at once make burst load design, calculation of the
parameter-collapse load at once make collapse load design, the selection of the chassis that
will be used in accordance with the load that has been counted, calculating the load tension and
load biaxial to calculate the load that will work on the chassis are the same. After calculating the loads that work on the casing step further is to choose a grade chassis that
will be used to protect the well, casing the best are selected is
a casing that meets the requirements in the
technical and ekonom. Are technically able
to withstand the loads that work on the casing
that is internally reusre and external
pressure, tension load. In economically, the
casing is planned must have cost as minimal
as possible The ANTARIS Field AOV-1 well
is an onshore development well. Interest
does drilling of wells AOV-1 fatherly increase production of oil. Well AOV-1 Field
Antaris is a well vertically to a depth of 600
m or around 1968.5 ft TVD, where wells
AOV-1 including wells shallow with a
target drilling informations Ngrayon. The
well AOV-1 consists of three stretch and one
section in each trayeknya, where 3 stretch
that is a stretch production, stretch intermediate,
stretch conductor. On each
casing has a target depth, to stretch production 7 " with the diameter of the hole
8 1/2" has a target with a depth of 0-600 m
(0 to 1968.5 ft TVD) and installation of the
casing shoe at the depth of the. Casing intermediate 9 5/8 " in diameter hole 12
1/4" having a target with a depth of 0-250 m
(0-820 ft TVD) and installation of the
casing shoe at the depth of the. Casing conductor 13 3/8 " in diameter hole 17 1/2" having
a target with a depth of 0-30 m (0 to 98.425
ft TVD) and installation of the casing shoe at the depth of the.
AOV-1 well planning requires some data
such as the parameter data for formation
pressure and fracture pressure, mud weight. The data are in the get of Drilling Daily
Report (DDR), Prognosis Drilling of wells
before and some source other like Mud Logs.
Production casing casing 7 " with a
borehole diameter of 8 1/2" installed at a depth
of 0-600 m (0 - 1968.5 ft TVD) and casing
shoe positioned at a depth of 600 m (1968.5 ft), with a mud density of 10, 1 ppg, formation
pressure gradient 0.4954 psi / ft and gas
pressure gradient 0.0115 psi / ft. The 7 "production casing using casing grade K-55; 20
ppf; BTC. The calculation results obtained
@surface burst load = 97.28 psi with a burst
load design @surface = 1072.811 psi, @shoe
burst load = 748.9 psi with a burst load @shoe = 823.79 psi. Collapse @surface load = 0 psi
with collapse @surface load design 0 psi,
collapse @shoe load = 1033.9 psi with collapse
@shoe load design = 1137.2 psi. Results of the
calculations are plotted into a graph design
casing can be seen in Figure 4.8. Casing with
grade K-55; 20 ppf; BTC has a collapse
resistance strength of 2270 psi, internal
pressure 3740 psi, joint strength 451000 lbs,
pipe body yield strength of 316 000 lbs. By
grade casing are on casing 7 " considered in
graphic and obtained safety factor respective Ni = 3.83; Nc = 2.19; Nj = 13.54. So that from the
results of the calculation of grade casings which
have had a power over big of burden who
worked on the case and take into consideration
of the safety factor also can be inferred grade
been able and can be used for wells AOV-1.
Intermediate casing casing 9 5/8 " with a
borehole diameter of 12 1/4" installed at a depth
of 0 - 250 m (0 - 820 ft TVD) and casing shoe
positioned at a depth of 250 m (820 ft), with a
mud density of 9 , 8 ppg, formation pressure
gradient 0.45 psi / ft and a gas pressure gradient
of 0.0115 psi / ft. Production casings 9 5/8 " use
casing grade K-55; 36 ppf; BTC. The result of
the calculation obtained load burst @surface =
355.15 psi with a design load of burst @surface =
260.85 psi, load burst @shoe =
390.66 psi with a design load of burst @shoe =
286.93 psi. Collapse @surface load = 0 psi
with collapse @surface load design 0 psi,
collapse @shoe load = 417.87 psi with collapse
@shoe load design = 459.66 psi. Results of the
calculations are plotted into a graph design
casing can be seen in Figure 4.9. Casing with
grade K-55; 36 ppf; BTC has a power collapse
resistance is 2020 psi, 3520 psi internal pressure,
the joint strength of 755000 lbs, pipe body yield
strength of 564 000 lbs. By grade casing are on
trajectory 9 5/8 " to be considered as a graphic
and obtained safety factor respective Ni = 9.91;
Nc = 4.83; Nj = 30.06. So that from the results of the
calculations of grade casings which have had a
power over big of burden who worked on the
case and take into consideration of the safety
factor also can be inferred grade been able
and can be used for wells AOV-1. The conductor trajectory casing is 13 3/8 " with a borehole diameter of 17 1/2 " which is installed at a depth of 0 - 30 m (0 - 98,435 ft TVD) and casing shoe is positioned at a depth of 30 m (98,425 ft), with mud density 9.6 ppg, formation pressure gradient of 0.4349 psi / ft and a gas pressure gradient of 0.0115 psi / ft. The conductor casing 13 3/8 " uses the casing grade K-55; 54.5 ppf ; BTC. The result of the calculation obtained load burst @ surface = 42.804 psi with a design load of burst @ surface = 31.484 psi, load burst @ shoe = 47.084 psi with a design load of burst @shoe = 34.633 psi. Collapse @ surface load design = 0 psi with collapse @ surface load design 0 psi, collapse @shoe load = 49.134 psi with collapse @shoe load design = 54.047 psi. Results of the calculations are plotted into a graph design casing can be seen in Figure 4.10. Casing with grade K-55; 54.5 ppf ; BTC has a collapse resistance strength of 1130 psi, internal pressure of 2730 psi, joint strength of 1038000 lbs, pipe body yield strength of 853000 lbs. By grade casing that the trajectory 13 3/8 " to be considered as a graphic and obtained safety factor respective Ni = 63.77; Nc = 22.99; Nj = 226.73. So that from the results of the calculation of grade casings which have had a power over big of burden who worked on the case and take into consideration of the safety factor also can be inferred grade been able and can be used for wells AOV-1.

The casing cost calculation is based on the casing requirements required in the construction of the AOV-1 Well in the ANTARIS Field. From the results of the calculation of the price of the casing corresponding grade that have obtained the total cost at every trayeknya. On the stretch production obtained a total cost of $ 31 037 or approximately USD 439 483 920, on the stretch intermediate obtained a total cost of $ 23 292 or approximately USD 329 814 720, on the stretch conductor obtained a total cost of $ 3,360 or approximately USD 47,5776 million. So, for the total cost of the whole of elections grade casing for planning the design of the casing wells AOV-1 is $ 57 689 or approximately USD 816 876 240. Values are still below the value of the budget that disedakan is $ 65,000 or approximately USD 920.4 million.

**CONCLUSION**

After carrying out the technical casing design planning process in the AOV-1 well, several conclusions can be drawn as follows:

1. The AOV-1 well uses casing grade 7 "K-55, 20 ppf, BTC, R3; 9 5/8 ", K-55, 36 pfp, BTC, R3; 13 3/8, K-55, 54.5 pfp, BTC, R3.  
2. The AOV-1 well has a target depth of 1968.5 ft TVD, there are 3 routes as a result of the determination of casing depth and hole geometry, namely: The Production route 0 - 1968.5 ft. TVD using a bit size 8 1/2 " and casing 7", this route Intermediate 0 - 820 ft TVD uses bit size 12 1/4 " and casing 9 5/8", Conductor route 0 - 250 ft TVD uses bit size 17 1/2 " and casing 13 3/8".

3. Production casing 7 "program has 1 section at a depth of 0 - 1968.5 ft. TVD with casing grade K-55, 20 pfp, BTC has a safety factor respectively Ni = 3.83; Nc = 2.19; Nj = 13.54. K-55 grade casing, 20 pfp, BTC is ideal because it can withstand the loads that work on the casing.

4. Intermediate casing 9/8 "program has 1 section at a depth of 0 - 820 ft. TVD with casing grade K-55, 36 PPF, BTC has a safety factor respectively Ni = 9.91; Nc = 4.83; Nj = 30.06. K-55 grade casing, 36 pfp, BTC is ideal because it can withstand the loads that work on the casing.

5. Program Conductor casing 13 3/8 "has 1 section at a depth of 0 - 250 ft. TVD with casing grade K-55, 54.5 PPF, BTC has a safety factor respectively Ni = 63.77; Nc = 22.99; Nj = 226.73. K-55 grade casing, 54.5 pfp, BTC is ideal because it can withstand loads that work on the casing.

6. The total cost incurred from planning the casing design of the AOV-1 well when the rupiah exchange rate against the US dollar exchange rate is 14,160 is $ 57,689 or around Rp. 816,876,240, of the total value for casing design planning is still under budget, which is provided company that is $ 65,000 or about Rp. 920,400,000.

**ACKNOWLEDGMENTS**

The author also thanks KSO PERTAMINA EP - BANYUBANG BLORA ENERGI which has supported the implementation of research so that this paper can be completed well, and also to all officers of KSO PERTAMINA EP - BANYUBANG BLORA ENERGI.
REFERENCES

- Adam, J. Neal. “Drilling Engineering a Complete Planning Approach”. PennWell Publishing Company, Tulsa, Oklahoma. 1985.

- Badu, Kaswir. “Pelatihan Teknik Pemboran TKT Juru Bor Perencanaan Casing”. STEM Akamigas. Cepu. 2007.

- Bourgoyne, Adam T. Jr, dkk. “Applied Drilling Engineering”. USA:, Texas. 1986.

- Chaerunnisa Inayah, dkk.. “Penentuan Desain Casing Pengeboran Sumur INY-X Berdasarkan Aspek Geomekanik Pada Lapangan Biru Sumatera Utara”. Padjadjaran Geoscience Journal.

- Fakultas Teknik Geologi. Unpad. Bandung. 2019.Husein Salahuddin, Didit Hadi Barianto. “Cekungan Jawa Timur Utara” Jurusan Geologi, UGM. 2016.

- Rabia, Husain. “Fundamentals of Casing Design”. California. Kluwer Group. 1987.

- Rahman, S.S., “Casing Design Theory and Practice”. Center for Petroleum Engineering. University of New South Wales. Sydney. Australia. 1995.

- Rubiandini, R. “Teknik Pemboran II”, Jurusan Teknik Perminyakan, Institut Teknologi Bandung. 2012.

- Subiatmono.P, Kabul Pratikno Avianto, Dingkaputra Dicky. “Prediksi Pore Pressure Menggunakan Metode D-Exponent Dan Eaton Sonic Log”. Jurnal Mineral Energi dan Lingkungan. Fakultas Teknologi Mineral. Jurusan Teknik Perminyakan, UPN Veteran Yogyakarta. 2017.

- "Drilling Report Lapangan BBE” PT KSO Pertamina EP – BBE, Blora, 2019.

- ;”Report Lapangan BBE” PT KSO Pertamina EP – BBE, Blora, 2019.