SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2023 **Issue:** 04 **Volume:** 120

Published: 06.04.2023 **http://T-Science.org**

Issue Article

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SELECTION AND CALCULATION OF CASING PIPES FOR PRESSURE AND DIRECTIONAL WELL CONDUCTOR

***Abstract**: The article presents the design calculation and selection of casing strings for the mine, elongated direction, as well as the conductor of the directional development well for the purpose of successful drilling of well No. 707 at the Western Cheleken field in the coastal zones of the coastal waters of the Caspian Sea.*

The materials of previously drilled wells and the guidance document instructions for the calculation of casing strings for oil and gas wells, as well as safety rules in the oil and gas industry were used for the design, calculation and selection.

This work can be useful and used to perform the tasks set when drilling directional wells, when designing the calculation and selection of casing pipes of mine, elongated directions, as well as the conductor in extremely difficult mining and geological conditions at abnormally high reservoir pressures.

***Key words**: strength, pressure, external, shaft, butobeton, preventer, wellhead, shoe, pipe, elasticity, cross-section, coefficient, fluid, extraction, liquid.*

***Language**: English*

***Citation**: Deryaev, A. R. (2023). Selection and calculation of casing pipes for pressure and directional well conductor. *ISJ Theoretical & Applied Science, 04 (120),* 70-75.

***Soi**: http://s-o-i.org/1.1/TAS-04-120-14 ***Doi**: crossref https://dx.doi.org/10.15863/TAS.2023.04.120.14

***Scopus ASCC**: 2209.*

Introduction

The design of wells is distinguished by the following casing columns, direction, conductor, intermediate and operational.

The direction is an element that secures the wellhead zone and prevents drilling mud and drilled rocks from eroding the wellhead. Most often, one such direction is installed in the hole, but two columns can be used for loose soils. This casing is cemented with butobeton to the wellhead. These pipes can be shaft and elongated. Shaft and elongated directions will not lie down for pressure testing.

The conductor is a column of pipes necessary for the isolation of unstable formations containing fresh and salt water, as well as for the installation of special anti–blowout equipment and other equipment for further safe drilling of the well. The depth of the conductor's descent when drilling ultra-deep wells in difficult mining and geological conditions of Turkmenistan reaches within 1000 - 1200 meters, and the diameter is 426 – 508 mm. The pipe is pressed [1, 2].

The selection of casing pipes and the calculation of casing columns for strength are carried out taking into account the maximum expected excess external and internal pressures when the solution is completely replaced by reservoir fluid, as well as axial loads on the pipes and the aggressiveness of the fluid at the stages of construction and operation of the well on the basis of existing structures.

The strength of the descending columns and the installed blowout equipment should ensure:

- sealing of the wellhead in cases of gas and oil occurrences, emissions and open gushing, taking into account the additional pressure necessary for their elimination;

- resisting the effects of maximum crushing loads in cases of open gushing or absorption with a drop in the level of drilling fluids, as well as in the range of rocks prone to fluidity.

- standards and specifications for casing pipes, as well as safety margin coefficients for the calculation of casing columns must be agreed with the bodies of the Main Standardization Service.

When calculating the conductor, it is necessary to take into account, first of all, those forces that can act on them not only during descent and cementing, but also during further deepening of the well below the shoe of the casing in question.

So, when calculating the resistance to crumpling, the smallest pressure is taken as internal, which may occur in the event of a decrease in the liquid level during absorption, or when replacing the high-density flushing liquid with which the column is filled at the end of cementing with a low-density liquid that will be used for further deepening of the well. The pressure of the crimping and, consequently, the greatest excess internal pressure is determined depending on the pressure that may occur in the column after the closure of the preventer installed on it in the event of an outburst during the deepening of the well, or on the pressure at the end of cementing of this column. When calculating the tension force of the string for strapping, possible changes in temperature and pressure during the period of further deepening of the well are taken into account. If the well is designed to inject a high-temperature liquid into the reservoir (or to extract such a liquid), it is also advisable to take into account the conditions and forces that may arise during the operation of the well [4, 5].

Stability of the conductor. Intermediate and operational columns are tied with a conductor so that the upper sections of these columns are stretched at any time after strapping. But the axial forces that stretch the inner columns act on the conductor as compressive. If at least a small upper section of the conductor is not cemented securely in the borehole, under the influence of axial compressive forces, it may lose stability and bend longitudinally.

The minimum depth of the conductor 's descent for the above conditions is determined by the formula:

$$L = V_1/V + 10m \quad (1)$$

where V_1 is the maximum volume of drill pipes lowered to the shoe of the next column, m^3;

V- volume of 1 m of conductor length, m^3;

10 m is the value below which the fluid in the conductor should not fall.

V_1- the maximum volume of drill pipes lowered to the shoe of the next column is determined by the formula (2) [3].

The bottom of the casing is equipped with a shoe pipe, with holes, the number of these holes is determined by the formula (2).

$$n = O/\upsilon F \quad (2)$$

where Q is the total flow of cementing units, m^3/min;

- The velocity of the cement mortar jet at the outlet of the shoe pipe, m/s (υ = 20 -25 m/s);

F is the cross-sectional area of one hole on the shoe pipe, m^2

The length of the pipe is determined by the formula (3).

$$h = (n-1)\times 60 \quad (3)$$

where 60 is the distance between the centers of these holes vertically, mm.

We calculate the distance between the centers of the holes horizontally, determining by the formula (4).

$$L = \pi D/n \quad (4)$$

where D is the diameter of the shoe pipe, mm

The elongation of the casing string as a result of stretching under its own weight is determined by formulas (5) and (6).

$$F = 0{,}785\left(D_{out.}^2 - d_{int.}^2\right) \quad (5)$$

where $D_{out.}$ - outer diameter of casing pipes, cm;

$d_{int.}$- inner diameter of casing pipes, cm.

The lengthening of the casing string is calculated according to the following formula.

$$\lambda = QL/EF \quad (6)$$

where Q is the weight of the casing string, MN,

L – column length, m;

E – modulus of elasticity, Mpa;

F is the cross–sectional area of the pipe, m^2;

Unloading during the descent of the casing with a check valve without refilling is determined by the following formulas [6, 8].

$$V_1 = \pi D_{out.}^2/4\times L \quad (7)$$

where $D_{out.}$ - outer diameter of casing pipes, m;

L – length of the column, m;

We find the mass of the displaced volume of drilling mud according to the formula (8) in tons.

$$m_{dr.m.} = V_1\rho_{dr.m.} \quad (8)$$

The weight of the drilling mud is determined by the formula (9) in MN.

$$Q_2 = m_{dr.m.}/100 \quad (9)$$

The discharge of the casing string is determined by the formula (10) in MN.

$$Q_{d.} = Q_1 - Q_2 \quad (10)$$

where Q_1 is the weight of the casing string in MN.

Unloading during the descent of the casing without a check valve is determined by the following formulas.

We determine the weight of the casing string Q_1 in MN.

We calculate the weight of the casing string in the drilling fluid according to the formula (11).

$$Q_2 = Q_1\left(1 - \rho_{dr.m.}/\rho_{m.}\right) \quad (11)$$

where rm is the density of the pipe material, t/m^3.

The discharge of the casing string is determined by the formula (12) in MN.

$$Q_{d.} = Q_1 - Q_2 \quad (12)$$

The calculation of the shaft direction and the elongated direction due to the low depth of descent for strength is not performed. Only the weight of the column is determined.

If, due to the absence of zones of gas and oil occurrences and an insignificant depth of descent, the conductor is not calculated for strength [7].

Table 1. Well design: Based on the combined pressure graph, the following columns are selected:

№/	Name of the hole	Diameter of casing columns, mm	Depth of descent of casing columns, m	Height of lifting of cement mortar, m
1	Shaft direction	720	10	butabeton
2	Elongated direction	508	50	50
3	Conductor	339.7	800	800

Let's consider the calculation of the casing string 339.7 mm (conductor) in the directional operational evaluation well No. 707 on the Western Cheleken field.

For the elongated direction, a casing turbine is designed according to the API standard Ø508 x 11.13 J-55 Batress.

Weight of the elongated direction:

$$Q_{c.} = g \cdot L_{c.} = 138{,}8 \cdot 50 = 6{,}94\,\text{tn.}$$

Casing pipes are calculated according to the maximum values of excess external and internal pressures in accordance with the "Instructions for calculating casing strings for oil and gas wells" - RD 39-7/1 – 0001-89 [11].

Table 2. Data for the calculation of Ø 339.7mm Conductor

Conductor descent depth	L_I = 800m
Drilling depth of the intermediate technical column	L_{II} = 2100m
Reservoir pressure at a depth of 800 m	$P_{res.I}$ = 106 kg/cm^2
Reservoir pressure at a depth	$P_{res.II}$ = 334 kg/cm^2
The density of drilling mud at a depth of 2100 m	$\rho_{dr.m}$ =1,68 kg/cm^3
The safety factor of casing pipes	n_1 = 1,125; n_2 = 1,1; n_3 = 1,75

The greatest internal pressure in the casing occurs expectedly at a depth of 2100 m, when the well is working with reservoir fluid, which is determined by the following formula:

$$P_{int.} = P_{wellh..} = P_{res.II} - 0{,}1 \cdot \gamma_{o.} \cdot L_{II} = 334 - 0{,}1 \cdot 1{,}0 \cdot 2100 = 124\,\text{kgf/cm}^2$$

The maximum pressure in the well is expected when the column is pressed on:

We accept $P_{pres.test}$ = 140 kgf/cm^2

The internal overpressure in the well when the column is pressed on water is determined by the formula:

$$P_{int.ov.} = P_{pres.test} + 0{,}1 \cdot \gamma_o \cdot Z - P_{res};$$

At Z = 0; P_{res} = 0; P_{int} = $P_{pres.test}$ = 140 kgf /cm^2.

At Z = 800 m; P_{res} = 106 kgf/cm^2; P_{int} =140 + 0,1·1,02·800 - 106 = 116 kgf/ cm^2.

The calculated internal overpressure when testing the column for tightness.

The external overpressure is determined by the formula:

$$P_{ex.ov.} = P_{res.} - 0{,}1 \cdot \gamma_o \cdot Z;$$

At Z = 800 m, $P_{ex.ov.}$ = 106 – 0,1 • 1,02 • 800 = 25 kgf / cm^2

Casing pipes Ø339.7 mm with a wall thickness of 9.65 mm, with a strength group of J55 steel with a Batress thread according to API are planned for descent into the well.

We determine the value of the safety factor when calculating the external overpressure for casing pipes designed for descent [10, 12]:

$$n_1 = P_{cr.} : P_{ex.ov.} = 79 : 25 = 3{,}1 > 1{,}125;$$

We determine the value of the safety factor when calculating the internal overpressure for casing pipes designed for descent:

$$n_2 = P_T : P_{pres.test.} = 192 : 140 = 1{,}3 > 1{,}1;$$

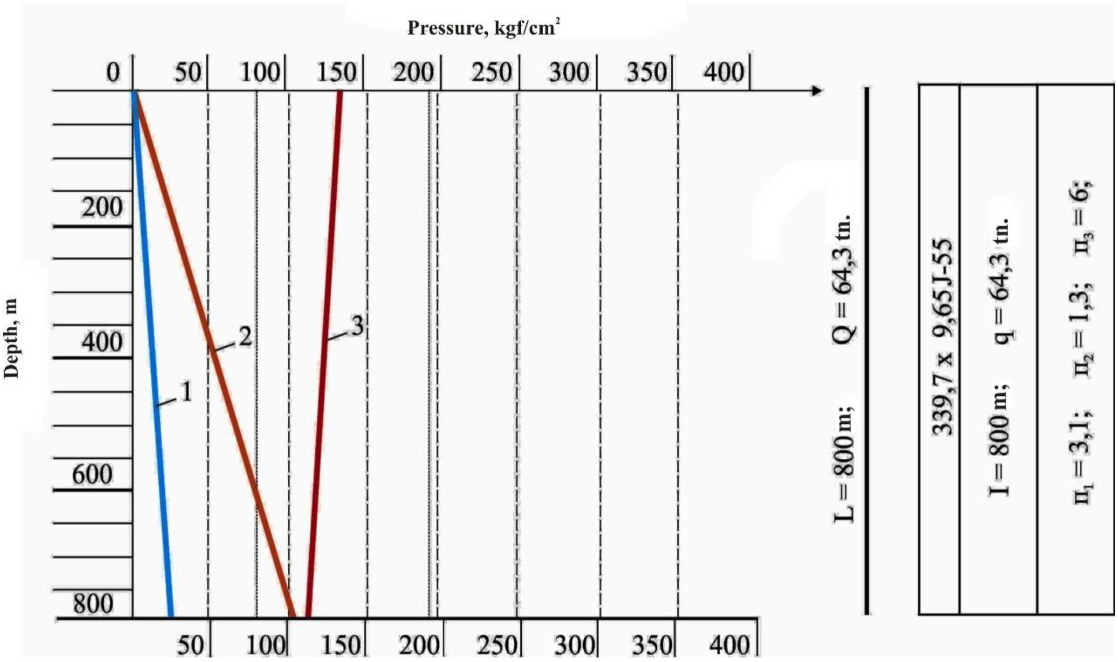

Figure 1. Calculation of excess external and internal pressure in the conductor 339.7 mm

1. Reservoir pressure
2. Internal overpressure when testing the column for tightness
3. External overpressure

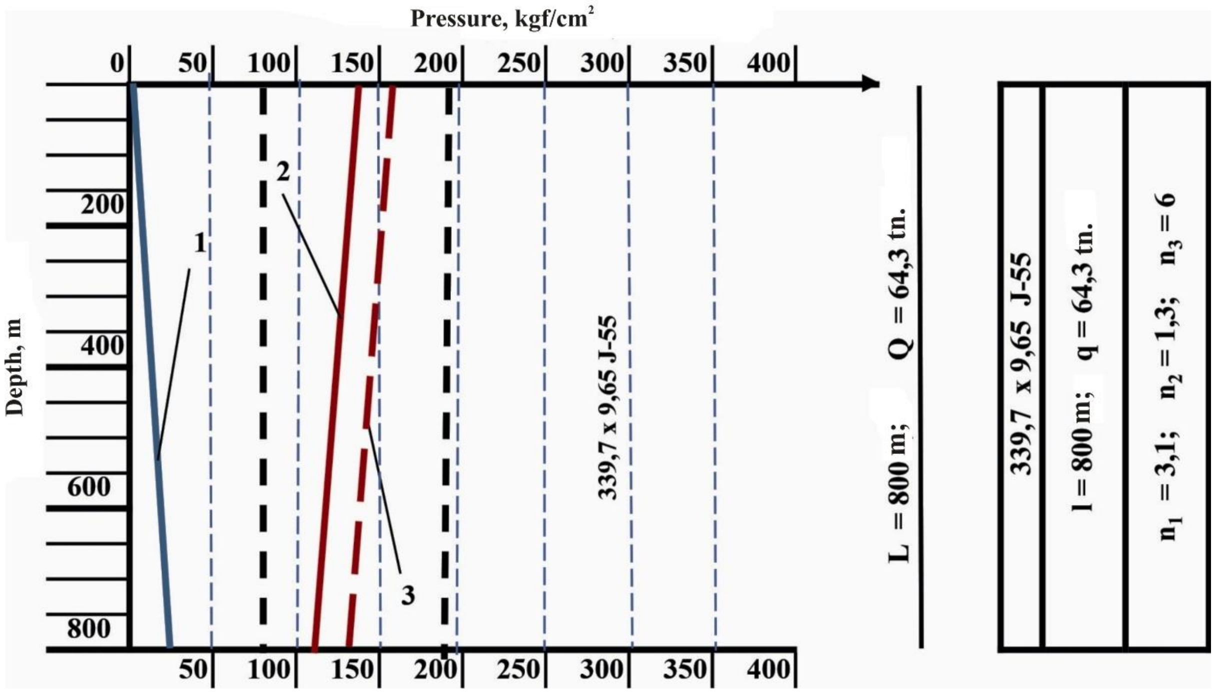

Figure 2. Calculation of 339.7 mm conductor for excessive external and internal pressure

We determine the value of the safety factor in the calculation of tensile strength for casing pipes designed for descent:

$$n_3 = P_{st} : Q_c = 387 : 64{,}3 = 6{,}0 > 1{,}75;$$

Where the weight of the casing pipes in the air to be lowered to the well is:

$$Q_c = q_c \cdot L = 80{,}4 \cdot 800 = 64{,}3t.$$

The graphical calculation of the conductor for excessive external and internal pressure is shown in Figures 1 and 2.

The selected casing pipe with a diameter of 339.7 mm with a wall thickness of 9.65 mm, the strength group of steel J55 with Battress thread meets the strength characteristics for all conditions for the descent of 800m [9].

The selected casing pipe gives the necessary clearance for drilling with a drill bit of 311.15 mm for an intermediate column with a diameter of 244.5 mm.

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