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# CONDITIONS OF A SINGLE INTAKE DESCENDING OF INTERMEDIATE CASING STRINGS OF AN EXCESSIVE WEIGHT COMPARED TO A DERRICK LOAD CAPACITY

*The way of the intermediate casing string descending is considered. It allows overcoming the limits of derrick load capacity through the weight transferring descending intermediate casing string on the cemented string that is based on the foundation. In particular, technology is developed where the weight of each additional string, as it builds-up, is equivalent to additional friction forces which arise in the enlarged area. Such a descent technology does not depend on the load capacity of the derrick load capacity, does not create loads on the basis of derricks as well as additional tensile loads in the string with an increase in its length. It is proved that if such a condition is met, all known restrictions for the descent of intermediate columns of any length in a single intake are removed. Authors determined descending casing string weight that is distributed over the previously installed and cemented string. It is suggested to distribute casing string weight on existing and cemented string.*

***Keywords:** drill string, borehole, drilling fluid centralizer.*

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# УМОВИ СПУСКУ В ОДИН ПРИЙОМ ПРОМІЖНИХ КОЛОН З ПЕРЕВИЩЕНОЮ ВАГОЮ ПОРІВНЯНО З ВАНТАЖОПІДЙОМНІСТЮ БУРОВИХ УСТАНОВОК

*Розглянуто спосіб спуску проміжних колон, котрий дозволяє подолати обмеження за вантажопідйомностю бурових установок за рахунок перенесення ваги колони, яка спускається на зацементовану колону як на фундамент. Зокрема, розроблено технологію, коли кожна додаткова вага колони при її нарощуванні еквівалентна додатковим силам тертя, які виникають на нарощеній ділянці. З'ясовано, що така технологія спуску не залежить відвантажопідйомності бурової установки, не створює навантажень на основу веж, а також додаткових розтяжних навантажень у колоні при збільшенні її довжини. Доведено, що, якщо така умова виконується, то всі відомі обмеження для спуску проміжних колон будь-якої довжини в один прийом знімаються. Установлено вагу обсадної колони, що спускається, котра розподіляється на раніше встановлену і зацементовану колону.*

***Ключові слова:** колона, свердловина, буровий розчин, центратор.*

**Introduction.** An intermediate casing string runs between the conductor and the drill string and serves for blinding the complicated zones or horizons overlying the design depth. Depending on the number of intermediate casing strings, the well is generally designed as a multi string. Most of the casing strings are descended into a well in one step. However, often at high depths, the string is lowered by parts (sections), respectively, into two or three steps. It is done in cases where the weight of the casing exceeds the lifting capacity of the drilling rig if, due to the insufficient strength of the casing, it is impossible to form a solid string for tension; if it is necessary to divide the string into parts due to the risk of complications occurrence. The length of the lower part (section) is chosen so that its tip would be above the shoe of the previous string at 50-100 m or 200 m higher than the possible zone of complications in the range of resistant rocks formations.

A characteristic feature of some gas deposits is the presence of abnormally high reservoir pressures, as well as massive gas deposits within thick gas-bearing formation. When constructing wells at gas fields it is necessary to consider its specific features:

1) the elasticity and compressibility of the gas that saturates the washing liquid during the drilling;

2) gas higher mobility and permeability compared to oil and water;

3) significantly higher pressure along the borehole from the wellhead to the bottom hole, compared to oil wells at uniform reservoir pressures;

4) high flow rates and gas velocities in the operation of gas wells, causing significant losses of formation energy. In order to prevent the disruption of a borehole in gas fields, the depth of the intermediate casing string descent should be deeper than that one of the oil fields.

Decreasing in a number of intermediate casing strings allows saving the time and resources in the process of a well completion. The necessity of descending each string severally is caused, basically, by an insufficient load-carrying capacity of derricks. Also, casing pipes use of domestic and sometimes foreign production cannot withstand the loads from a dead weight of long casing string. Nowadays the technology of descending the heavy casing strings is known. It uses heavy hydraulic jacks installed at a wellhead. But it solves the problem partially since the restriction of a maximum length of a casing string is still there.

To prevent the gryphon occurrence, before the perforation in gas-bearing or pressure formations, it is necessary to use the conductor or an intermediate casing string to cover the whole soil unit capable of absorbing the washing liquid and through which it is possible to for gas to leak into a surface. For gas fields with a thick gas formation and abnormally high reservoir pressure, the number of intermediate casing strings and the position of their liners (shoes) should provide a drilling without absorption of washing liquid and associated emissions and blowouts.

**Analysis of recent sources of research and publications.** In prosperous countries, the drilling is carried out by using the drilling rigs of high carrying capacity which allows the descending of heavy casing strings in a single intake. For example, at the well No. 1 at Bertha Rogers (USA), a 426 mm casing string with 6580 kN of weight was descended to the depth of 4202 m [1]. In case of an excess of the column weight over the load capacity of a rig, a special mobile equipment is used, it is equipped with the powerful hydraulic jacks with a high speed of its bearing supports. With this equipment at the well No. 1 in Medoip (USA) a 508-millimeter casing string with length of 3800 m and weight of 9500 kN was successfully descended [2]. The maximum depth and weight of the column, which is descended using this equipment, are determined by the load of threaded joints.

In our country, the methods of heavy casing columns descending have been developed and applied by the way of their weight decreasing, mainly by increasing the pushing out force. There are a number of technologies for descending heavy casing strings. The simplest way is the descent of the casing strings with the replacement of the drilling mud in it for a lightweight liquid with partial emptying. However, in this case, upon the restoration of the drilling mud circulation, there is a violation of the hydrostatic balance in the well. In the annular space, the density of the drilling fluid decreases, and in the pay zone, there are conditions created for the formation of the reservoir fluids inflow and its further extraction to the surface, and hence the conditions of water and gas oil manifestations and related complications. This inevitably causes the borehole stability deterioration.

Given the fact that the weight of the column increases by the weight of the volume of additional fluid, during the upward movement, the forces of resistance are added (10 - 15% for vertical wells). There are difficulties in undermining the column at the time of its extending with the next pipe. To go beyond the capacity of the drilling rig, it is necessary after the circulation to empty the column again to the previously achieved value, using a compressor and descent of a drill string [3]. The allowable amount of emptying during the descent of columns with impenetrability is limited to the condition of four-fold strength of pipes for crushing. The above limitations do not allow the heavy casing strings to be lowered in a single gear.

**Identification of general problem parts unsolved before.** An important role in the well drilling is the right choice of well design, which would ensure the creation of a durable and hermetical channel, stability of the borehole during the entire period of production, preventing the inner flow, and also allow performing well repair work. To reduce the weight of the casing string on the hook, the device was proposed to create an additional frictional force when descending the string into the well [4]. Friction governed by backfilling sand or other granular material that fills the annular space between the casing that goes down and the cylinder. The sand falls into the open upper cylinder funnel and pours off at the lower end through a series of narrow openings. The rate of sanding is regulated by compressed air. In the upper part of the cylinder, a hydraulically controlled telescopic device is provided for the possible reduction of the annular space intersection, if the speed of the column rise increases.

The creation of significant frictional forces provides the necessary clamping force [5]. When it is in accordance with the weight of the string, the device must be of a considerable length, which is difficult to achieve. Significant work on reducing the sections number of casing strings was carried out by the laboratory of techniques and technology for wells completion of the State Research Institute of Drilling Technology. Thus, a 340-millimeter intermediate casing string was descended at a depth of 4600 m by three sections instead of five according to the project. It is summarized and analyzed existing methods of facilitation of casing strings during their descent into wells, as well as possible variants of cementation. Nonstandard technologies of columns descent have been worked out, the realization of which is promising, but technically complex and has a number of limitations [6, 7]. Such technologies include the "pontoon" method of releasing heavy casing strings and the descent of the string by increasing the density of the fluid in the annular space.

In general, the goal is to develop the issue of reducing the sections number of casing strings. It has been developed in two directions:

- increasing of lifting capacity of drilling rigs, the creation of special jacks for descending the casing strings;
- increasing the lifting force acting on the string in a liquid mud.

The first way allows to execute the descent of the heavy casing strings and has only one limitation for the load in the threaded joints. When applying welded strings - is the limiting tensile stresses on the pipe body.

The second way is technically more complicated and requires additional casing installation, which adds additional restrictions. The first method of descending the casing in a single intake is real and limited by loads. In the second method, the sections number of the casing descending decreases by 30-60%.

**Basic material and results.** The descent of the string should be done after conducting geophysical surveying, preparatory works. Inspection and preparation of the casing elements were carried out primarily on the tube base. After a visual inspection, the pipes were subjected to instrumental control, with defectoscopic installations, calibers. The total length of the imported pipes by 5% exceeded the length of the casing. The reserve consists of the most robust pipes. Before the descent of the casing, the well was washed for 2-3 cycles. The rise of the casing pipes on the drill was carried out in the presence of protective rings for a thread. Each tube is numbered, measured and verified by external inspection. A template was passed through each tube.

The previous assembling of the productions string was carried out with the AKB-3M tool, smooth rotation of the casing from its capture to the complete stop, and then the quality of assembling was checked on the number of complete threads that remained above the coupling.

Fastening of the threaded joint was carried out with AKD-3M tool with maximum short-term torque. In the normal threaded connection, the last thread coincides with the end of the sleeve, a deviation of 1 thread is allowed. Intermediate washings were carried out from a depth of 1200 m every 300 m at least one cycle. In the process of flushing-out of well, pressure, circulation, and parameters of the drilling mud, level in the inflow containers should be controlled.

It is proposed another way to descend the intermediate casing strings, which allows overcoming the limitations of the drilling rigs lifting capacity by transferring the weight of the casing string to the cemented column as a foundation. Using this approach to the task of descending into of intermediate strings in a single operation, the weight of which exceeds the capacity of drilling rigs, there are no restrictions as to the carrying capacity of drilling rigs, as well as for the loads. Thus, the weight of the column on the hook can only be a part of its actual weight.

The implementation of such technology can be carried out by various technical means.

The essence of the technology lies in the fact that each additional weight of the string at its build-up is equivalent to the additional forces of friction that arise in the enlarged area. Such a descent technology does not depend on the load capacity of the drilling rig, does not create loads on the basis of the derricks, as well as additional stretching forces in the string at an increase in its length. If this condition is fulfilled, then all known restrictions for descending the intermediate casing strings of any length in one step are removed.

With this approach, the weight of the lowered casing is divided into a previously installed and cemented casing string, the action of the distressed loads moves down under the shoe of a previously installed string of a larger diameter. The diagram of tensile stresses in the string changes.

It is considered the technology of the descent of a heavy casing by an example of a hypothetical well.

In the well to a depth of 6800 m, it is necessary to lower the casing string with a diameter of 245 mm with a wall thickness of 12 mm of strength group M, which weighs 4760 kN. The string consists of casing pipes OTTM1 with a normal diameter of the coupling, a tolerable stress of 3870 kN and a limiting weight in the wedge holds of 4350 kN. The descent is carried out by a drilling machine with a carrying capacity of 2000 kN with a 324-millimeter column set in the well at a depth of 3600 m.

The descent of a 245-millimeter column weighing 700 kN is based on standard technology at a depth of, for example, 1000 m. Further descent is carried out on a rigid elastic centralizer (Fig. 1), each of them, as calculations show, in the gap of strings with diameters of

245 and 324 mm, can withstand a weight of 12 - 16 kN with a coefficient of friction «metal – metal» 0,17. When installing the centralizer while building-up the string, the rest of the weight can be unloaded to a 324-millimeter string.

To make it possible to break the column of wedges, a telescopic connection is established in a 245-millimeter string with a stroke of up to 0.5 m. The weight of the string under the telescope must be zero or less at the design depth and the casing string should completely hang on the centralizers.

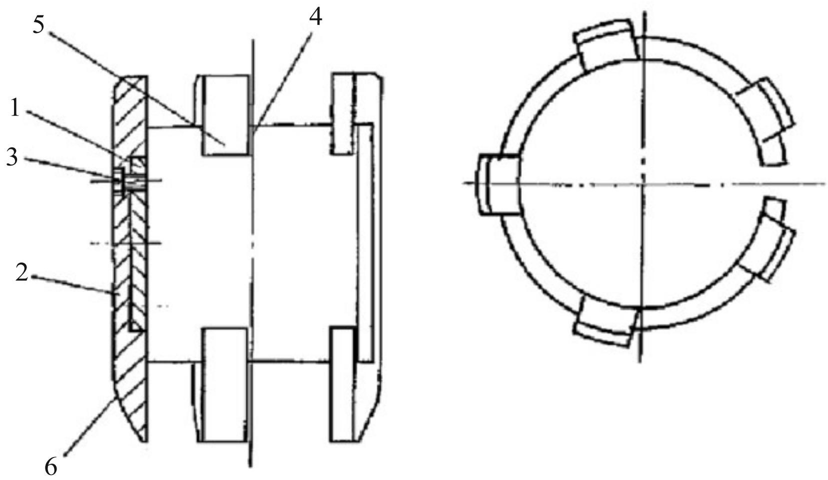


**Figure 1 – Unloading centralizer for well pipe strings:**
1 – spring element; 2 – guide lining; 3 – screw;
4 – slots; 5 – ledges; 6 – chamfers

It is allowed to not install telescopic string connection, but use the tension of the string to remove the wedges due to its lengthening. At the same time, only the part of the string whose weight is located on the hook will lengthen, and the lower part will be unloaded on the centralizers.

When the 245-millimeter string of 324-millimeter shaft leaves the open barrel, the weight of the 245-millimeter string will be increased by the weight of the column part which hangs on the centralizers. The centralizers will not work in a barrel with a nominal diameter of 295 mm.

By extending the string with the installation of the toruses center, it is possible to compensate the weight of the column in an open barrel length of 3200 m and leave the convenient weight to work with (approximately 200 - 300 kN) to hang on the hook.

It should be noted that the actual depth of the descent of a 245-millimeter column is equal to the load in an open barrel from a 324-millimeter column.

In this case, it is considered a 245-millimeter casing string with weight of 6390 kN (3870 kN from a boot of a 324-millimeter string plus 2520 kN in a 324-millimeter string) at a length of 9100 m in one step.

In addition, due to the lifting force of a drilling mud with the density of 1200 kg/m$^3$, the length of the string can be increased by 15,28%. If steel pipes of the grade R-110 were used in an open barrel, the weight of the string, lowered in one step by a drilling machine with a carrying capacity of 2000 kN, can reach 8710 kN, which is equivalent to 12443 m. In the Kola extra-deep well, it is possible to lower a 245-millimeter string in one step to a depth of 14344 m with a drilling density of 1200 kg/m$^3$.

The necessary and sufficient condition for the descent of the column in one step is the stability of the well bore during the descent.

**Conclusions.** The proposed method allows lowering heavy casing strings into a well in one step. The maximum weight of the string does not depend on the load capacity of the drilling rigs. The weight of the string is limited by the carrying capacity of the threaded joints of the string part, which is in the open barrel, and the weight of the string to the bottom of the previously lowered string.

The benefits of the lowering a casing string in one step include: no need in using the admission tool, which by its own weight limits the weight of the section; no need in equipping the string with connecting devices, as well as the use of disconnectors; reducing the wear of the columns in the docking areas where it reaches the highest values; the parallelism of the strings creates normal conditions for cementing; changing of the forces diagram in the string; more favorable conditions for the column sealing; no need to tension the string; shortening the borehole. An essential disadvantage is the lack of the strings ability to «wander».

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