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Teaching Material, Books, Publications versus the Practice: Myths and Truths about Installation and Use of Downhole Safety Valve

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Abstract**—**The paper is related to the safety of oil wells and environmental preservation on the planet, because they require great attention and commitment from oil companies and people who work with these equipments. This must occur from drilling the well until it is abandoned in order to safeguard the environment and prevent possible damage. The project had as main objective the constitution resulting from comparatives made among books, articles and publications with information gathered in technical visits to operational bases of Petrobras. After the visits, the information from methods of utilization and present managements, which were not available before, became available to the general audience. As a result, it is observed a huge flux of incorrect and out-of-date information that comprehends not only bibliographic archives, but also academic resources and materials. During the gathering of more in-depth information on the manufacturing, assembling, and use aspects of DHSVs, several issues that were previously known as correct, customary issues were discovered to be uncertain and outdated. Information of great importance resulted in affirmations about subjects as the depth of the valve installation that was before installed to 30 meters from the seabed (mud line). Despite this, the installation should vary in conformity to the ideal depth to escape from area with the biggest tendency to hydrates formation according to the temperature and pressure. Regarding to valves with nitrogen chamber, in accordance with books, they have their utilization linked to water line ≥ 700 meters, but in Brazilian exploratory fields, their use occurs from 600 meters of water line. The valves used in Brazilian fields are able to be inserted to the production column and self-equalizing, but the use of screwed valve in the column of production and equalizing is predominant. Although these valves are more expensive to acquire, they are more reliable, efficient, with a bigger shelf life and they do not cause restriction to the fluid flux. It follows that based on researches and theoretical information confronted to usual forms used in fields, the present project is important and relevant. This project will be used as source of actualization and information equalization that connects academic environment and real situations in exploratory situations and also taking into consideration the enrichment of precise and easy to understand information to future researches and academic upgrading.

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I. Introduction

THE security may be comprised well as their efficiency to mitigate leakage to the environment and is an important characteristic of an oil well. One way to reduce leakage during the production phase is to carry out maintenance interventions that preserve well in safe situations and spare safety barriers.

The wells security system has intended to protect the surface of eventual eruptions that may occur during the phases of drilling, completion and production. In the completion phase, the column is formed by tubes, flow control valves, expansion joints, profiles for tools (nipples) and the security device formed by subsurface safety valve, also known as downhole safety valve (DHSV).

The safety column is made with the set of production, casing, damping fluid and Christmas tree and BOP [1]. The safety device must provide two barriers throughout the productive life of the well and also during installation or intervention for maintenance. The first security barrier for a production well is composed of: production liner (below packer); packer; production packer tube to the DHSV; and the safety valve.

The second barrier in turn is composed of the production casing above the packer, pressure hoster (housing) or head production; column and suspensor; Christmas tree (during production) or mechanical plug (plug or BPV) during the intervention. The two sets of security barriers function independently, the failure of a safety system does not compromise the functionality of the other, thus performing its function and mitigating the possible lack of control [2].

The construction of wells in water depths ever deeper has been accompanied by the increase of equipment in relation to the pressure class and especially security. Therefore, nowadays, there are some types of DHSV's. Some types are not used anymore, example retrievable DHSV (Wireline Retrievable) for restricting flow and result in several problems. Other types like DHSV nitrogen chamber are constantly being improved due to great pressures and water depths, it is the main use today [3].

The fence the oil well safety universe will be discoursed in more depth article about DHSV. Aspects will be addressed: functionality, features, way of installation, advantages and disadvantages, environmental importance and possible penalties imposed by non-use of these valves [4].

Being thus the aim of this study is a survey of information, based on articles, books, research and interviews to produce a database with deep analysis of subsurface safety valves (DHSV), addressing their characteristics and functionality. To execute a theoretical idea of confrontation published with current forms of use and management commonly used in Brazil, according to information obtained through a large Brazilian oil company. They were also executed deepened analysis of the functional aspects addressing all the characteristics of the types of DHSV's, demonstrating the ways and theoretical conditions published use of these valves, with more updated information collected in interviews and used in positions of confrontation for the production of case study.

II. DHSV

The DHSV is the main component of the first well safety barrier. The valve is part of the production column positioned 30 m below the sea or land, which in turn has the function of closing the well in case of emergency. The valve installed inside the well will not be damaged by fire or collision, which guarantees its operability in emergency situations. The safety standard that regulates well safety of Brazilian oil companies is N2765 [5].

The DHSV is a surface-operated safety device, which may be of the spherical type which is either a flapper or a flapper-type ball which is a flow tube moving downwards opening it, but currently the Brazilian Oil only uses the flapper type being the most reliable, it is normally installed at 30 m, below the mud line [2]. Fig. 2 shows the use of the Christmas tree, the location of the DHSV, the panel that controls the valves and the column hanger.

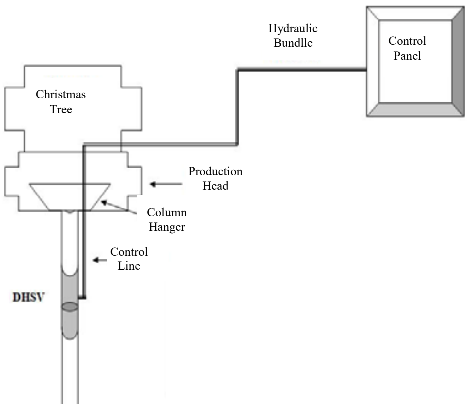
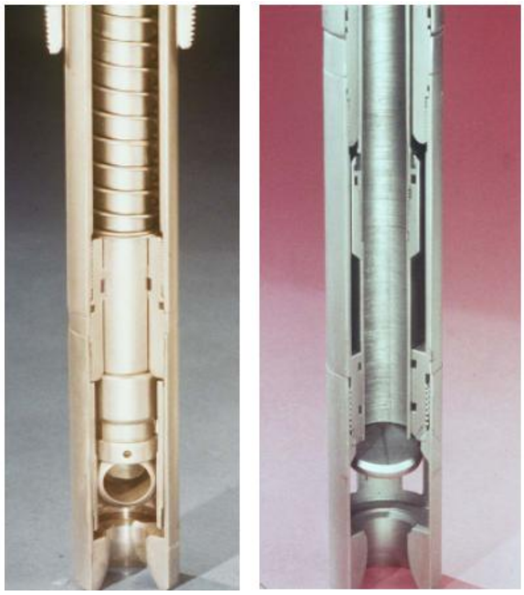


Fig. 1 Schematic drawing of the DHSV circuit

The depth of the valve has the ideal conditions for the formation of hydrate envelopes, since it has the following factors: Temperature, pressure, presence of water and oil. Its installation can vary, being seated below the bubble point of the produced oil, to avoid the formation of hydrates or to prevent the production of sand by reflux in injector wells. In cases where the drilling of some other well is provided in the same template, the DHSV must be installed below the programmed depth of deviation, however in some cases as it occurs in the North Sea the DHSV is installed at a great depth below the point Bubble to prevent gas migration and subsequent hydrate formation [6]. Fig. 2 shows two most commonly used types of DHSV.



(a) (b)

Fig. 2 Types of DHSV - (a) spherical type and (b) flapper type

When a well or platform requests an installation of a DHSV, all parameters, temperature, pressure at valve height, pressure differential of the column, the diameter will be required for this information to be inserted into a manufacturer's software, and This software supplies the pressure of the spring or the nitrogen chamber, related to the well, so that it is properly installed and adjusted the valve.

The main purpose of the valve is to act as a well control device in case of loss of the security barrier of the Wet Christmas Tree – WCT [2]. It is considered a safety device positioned in the production column, which allows the immediate closure of the column, stopping the flow of oil and/ or gas, if any serious problem will occur with the surface equipment.

A. Basic Principle of the DHSV

The basic principle of the DHSV is a spring that remains compressed under external pressurisation on the surface keeping the valve in the open position. If the line is depressurised, the valve closes for any reason. At the platforms, a pressure of 5000 PSI is injected, however the valves are normally opened with 3000 PSI, and the 2000 PSI is overpressure. This overpressure, to this day, has never damaged any valves. The closing pressure is in the range of 500 to 1500 PSI. The operation is carried out by increasing the pressure of the control line, controlled through the hydraulic panel that acts on an internal drive piston, moving the flow tube down, integral with the piston with this causing the opening of the flapper and at the same time, compressing the spring. Therefore, as long as there is sufficient pressure on the control line, the flapper will remain open. In a sinister situation where the control line will be depressurised, under control or not, the spring will expand causing the flow tube to move upwards and consequently closing the flapper, interrupting the flow of the well [2].

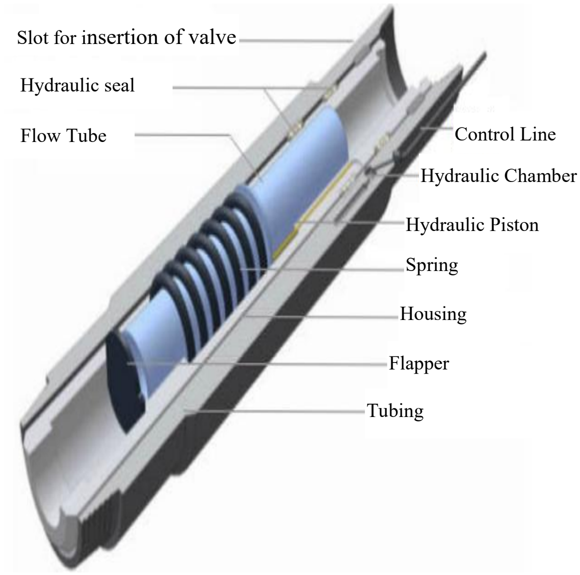


Fig. 3 Schematic drawing of DHSV

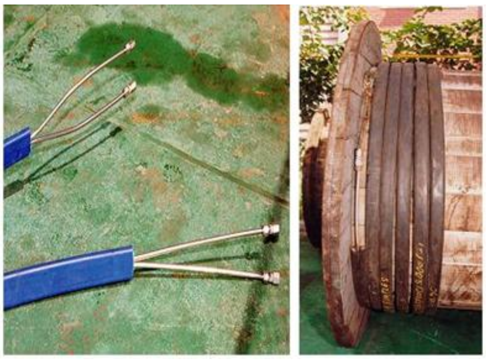


Fig. 4 Double Encapsulated Line and Coil of Control Lines

B. DHSV Installation

The DHSV and the control lines are shipped to the production unit for installation, but tests were carried out in the workshop and the opening and closing pressures for opening and closing start and finish were checked. The bench pressures are checked with the valve in the vertical position, as there would be significant differences if the reading was performed horizontally, in the order of 15% to 20%. DHSV's are screwed with pre-established torques, pup joints above and below the DHSV, favoring their installation in the production column. From the workshop, all DHSVs are shipped to the platform, with the control line supplied with HW-525, previously treated with bactericidal fluids and buffered for shipment. The control lines are sheared cold.

Simple non-encapsulated control line with ¼" outer diameter is always used in the installation in the case of wells with head in the production deck or double and encapsulated with 3/8" outside diameter in the case of submarine wells Fig 1. The control lines are fixed to the production tubes by means of metal belts. After installation of the DHSV, the system is pressure tested, since interface faults are causes of valve closure [7].

C. General Classification of DHSV

The DHSV has two ways to be installed: Tubing Mounted and Wireline Retrievable. It can be driven by: Controllable surface valve or flow choke [2]. According to the equalization the DHSV can be: auto-equalizable or non-equalizable.

The DHSV screwed into the column known as Tubing Mounted, are installed directly into the production column, ensuring greater reliability, cause less restriction to fluid flow and are more expensive than wireline retrievable. The disadvantage of greater relevance is that in case of malfunction or any problem that needs to be removed, it would be necessary to remove the Christmas tree, the production column and the control lines [8].

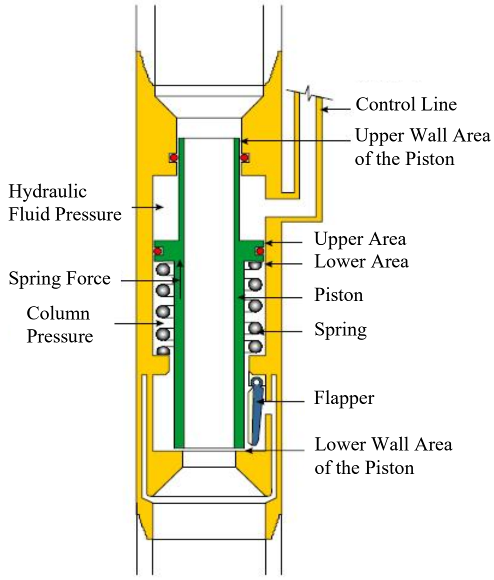


Fig. 5 Schematic drawing of the DHSV tubing mounted

The retrievable DHSV (Wire Line Retrievable) consists of a nipple seated valve, usually installed after completing the well. The nipple has a profile where the valve is installed with wire. Each profile is known to seat objects with wire and has a sealing area where the gaskets are secured in a locking area.

Table I shows a comparative table between the two types of DHSV.

Controllable surface valves are generally closed (fail safe close) regardless of the conditions and flow characteristics of the well can be tubing mounted or wireline retrievable, are opened when a pressure is applied through a hydraulic line, whether the valves are closed, the hydraulic line pressure is drained through the control panel on the surface.

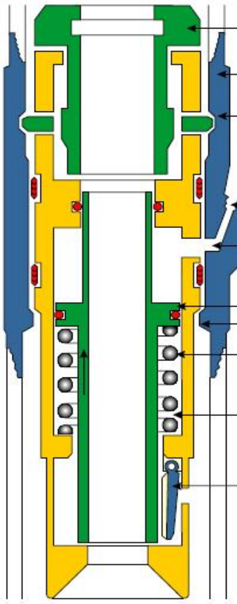


Fig. 6 Schematic drawing of retrievable DHSV

TABLE I
ADVANTAGES AND DISADVANTAGES

Tubing Mounted	Wireline Retrievable
Less restriction on flow	Greater flow restriction
Longer life span	Has a shorter service life
Requires column maneuver for replacement in case of failure	Does not require column maneuver in case of failure
High acquisition cost	Low acquisition cost
Less restriction on flow	Greater flow restriction

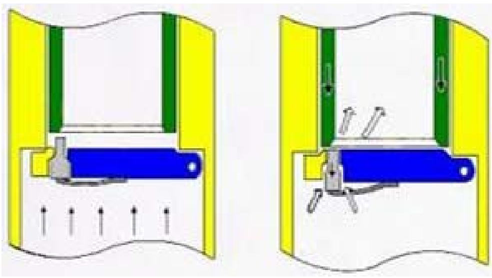


Fig. 7 Self-equalization mechanism

The non-controllable surface valve, known as the flow rate valve and storm choke is generally opened and modified by the well flow variation when the well flow is greater than that used in its calibration. In this way, it causes the closing and its functioning is by pressure differential. The main advantage is not to use a control line, but the calibration adjustment, compared to the characteristics of the flow, is a disadvantage. It has a high occurrence of problems and they are retrievable.

As for the equalization of the DHSV, there is the auto-equalizable that does not require an external source of pressure to standardize the pressures above and below the sea (flapper or spherical) for valve to open, since it has a self-equalizing system. Some types of systems allow internal valve leaks. It will only be opened after the equalization of the pressures above and below DHSV; otherwise the well will eventually produce through the equalization hole.

A non-equalizable DHSV, the system of seal (flapper or ball) will only be actuated for opening after equalized the pressure above and below the valve. Fundamentally, the pressures above and below the valve sealing device are standardized through the inside of the column using gas, oil from another well or diesel, thereafter the control line is pressurized to open the DHSV and thereby maintains the open with safety margin.

The stimuli originated from the production of oil fields in deep waters (> 600 meters), caused new equipment to appear to satisfy the existing conditions, among them the DHSV with a nitrogen chamber (N_2).

In addition to servicing the deep-water installation, the N_2 DHSVs have the requisite low operating pressure of the control umbilicals and greater reliability in operation (Fig. 8).

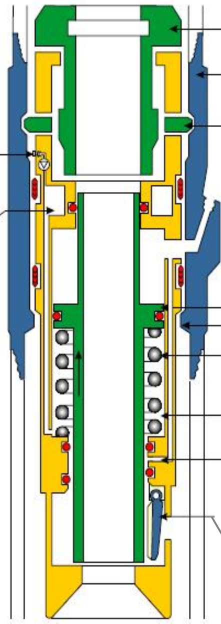


Fig. 8 Schematic diagram of DHSV/N_2

Among the characteristics we can mention: The existence of N_2 chamber, insensitive to well pressure; Have two independent control lines; And be a failsafe system that ensures its operation. The N_2 chamber, pre-calibrated for a given valve installation depth, adds pressure to the spring, contributing to valve flapper closure and DHSV surface operating pressures. If there was no N_2 chamber, an extremely strong spring would be required as compensation, implying a disproportionate relative increase in pressure in the hydraulic panel (usually limited to 5000 PSI) to operate the valve, attributed to the high differential delta in the linear force behavior X constant spring force.

Having two control lines became necessary due to the clogging of one of them has always been the major cause of intervention in wells with problems in DHSV.

The N_2 chamber is intended to compose the resultant of forces acting in the direction of closing the DHSV when there is a valve failure.

III. Method

In the development of this article, in addition to much research on scientific articles and manuals of petroleum companies, a case study was carried out inside the facilities of an oil company.

During technical visits, various characteristics of the valves were addressed, and the current usage of such valves by the oil company was exemplified in the fields of production and development of both oil and gas. Through, demonstrations and exhbitis of several tools and through long discussion, a significant part of the published material was exposed. On the other hand, the material related to the topic is very scarce, outdated and contains erroneous information, according to the oil company's use in the Brazilian development fields). Such issues were the reason for the research, which is detailed in later sections of this article. The results obtained from many ovservations are considered.

IV. Results Obtained

The results obtained from the technical visits to DHSVs in the workshop as well as the technical reports analyzed are hereinafter discussed.

A. Valve Installation Depth

The subsurface safety valve is a component of the production column that is positioned about 30 meters below sea level [2].

According to clarifications obtained during surveys, on studies in progress, the reports of the standard procedures, carried out by the oil company in Brazilian exploration fields, it can be observed that the DHSV is installed outside the 30 meters, which were previously considered standard. However, in case of a deeper installation it would be able to escape from the ideal point according to the temperature and the pressure of the formation of hydrate envelopes. Generally, the valves are installed much lower than 30 m deep to escape from the bubble point (gas discharge from the well oil). This occurs in certain wells and installation in the range of 800 m to 1000 m of the mud line.

B. Water Depth for DHSV with Nitrogen

The challenges arising from the production of oil fields in deep waters (> 700 meters), gave rise to new equipment to meet the existing conditions, among them the DHSV with nitrogen chamber [1].

However, according to reports and field experiments, the use of DHSV's of N_2 from 600 meters of water depth was taken as standard by some oil companies in Brazil, because in that depth the sum of forces that acting against the well would not be sufficient without the action of the nitrogen chamber pressure.

C. Equalization of Valves

A reversal was noted in the conclusion of 1989, in which valves without self-equalization were more reliable [4]. Probably due to the evolution of the projects, currently the DSSS with auto equalization are more reliable than those without auto equalization.

As seen in the visit made to the headquarters of the oil company, the self-equalized valves are not being used. Such valves have an elastomeric seal in the "equalization valve" which is inside the flapper. This is a weak point for future leaks, so it is preferable to use the equalization procedure of the column above and below the flapper instead.

In the production column, there is the gas lift valve that when the well is stopped maintains pressure below the flapper and is therefore susceptible to failures in the tightness test, since after closing the flapper the well will continue to inject through the VGL until the injection is closed of gas. This pressure will accumulate below the flapper, so it is important that we know the maximum pressure that can accumulate below (compressor pressure of the production unit) to know how much we need to equalize the flapper and reopen the DHSV.

D. Valves in Non-Flow Wells

Historically, spare safety equipment was required for wells in which the oil flows towards the surface is independent of mechanical stimulus (Flow Wells) [9].

The use of DHSV's in injector wells was abolished. However, as an ANP norm and custom all Petrobras wells, whether or not they are of production, or injection, have DHSV [1].

The DHSV use was due to the accident at Macondo in the Gulf of Mexico when about 780 million liters of oil was spilled in deep water between April 20 and July 15, 2010. This event killed approximately 6,000 turtles (of five species, all endangered), 26,000 marine mammals and 82,000 seabirds, among other serious damages.

E. Mechanism Types - Flapper or Sphere

According to several publications, operational mechanisms may be of flapper or spherical types [10]. However, valves which are spherical are not normally closed, the basic principle of a DHSV is to be closed, so spherical valves would not be safety valves, so usually DHSV's are flapper type. There are few wells in the hydraulic isolation valve formation which serve as the barrier in the completions, these are spherical type, however, they need pressure cycles to open and close, therefore they are not considered safety valves

V. Conclusion

After the diverse information obtained during visits to the oil companies, the current article aims to develop a comparison between different scenarios of subsea wells in the productive phase. There are several safety equipment, however was chosen as the main subject of DHSV from the unavailability and scarcity of research sources.

In this paper, a case study was developed on DHSV's, a subsurface safety system. Becoming a challenge, as there is not much content in books and internet publications about this issue, which has stated as important source of future research, given its vast and easy-to-understand baggage of information.

Throughout the study, it was observed that DHSV is an essential subsurface safety equipment required by the ANP in all wells being injectors, bursting or not.

It can be seen in this article that retrievable DHSV's are not currently installed in new wells and are only used in wells that have been in operation for years. And when there is an intervention in the well, the retrievable DHSV will be replaced by the screw, because it does not restrict the flow and its reliability is greater the coiled DHSV's, even at higher cost, has been the main option.

By means of the above, it can be concluded that the wells are being drilled more and more in deeper water depths, with that the oil production is several thousand meters from reaching the reservoir with oil. Due to this fact, new technologies such as DHSV with nitrogen chamber have been developed, where it can be verified a modernization that makes the DHSV/N_2 insensitive to the well. There is an internal passage and one on the side of the piston for the arrival of the pressure in the well, instead of being as conventional as the well pressure reaches below. Thus, the resultant of the forces is lateral, not upward, not causing a differential, thus confirming the insensitivity of the nitrogen chamber to the well.

When the research on DHSV with a nitrogen chamber began, it was thought that there was nitrogen in the pressurization lines and this thought is completely erroneous, because the pressurized nitrogen only exists inside the chamber, which is installed previously pressurized by nitrogen. The nitrogen pressurizing cannot be changed, since it has already been set at the factory. Nitrogen pressurization cannot be changed since it has already been factory adjusted and to date no failure caused by the depressurising has been reported.

A much higher use of DHSV with nitrogen chamber was observed because the water slides were increasing. But the conventional DHSV is still important because there are still many wells with water depths of less than 600 meters.

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