

## Research and Field Application of Top Screen Cementing Technology with the Salvaging Type Plug-Drilling-Free Tool

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### Abstract

Top screen pipe cementing technology of casing in horizontal well has been one of the main completion, especially for developing reservoirs with bottom and edge water and heavy oil reservoirs. Main drawbacks of screen top cementing completion technology in horizontal wells are casing wear in the process of drilling plug and burrs in the inner surface after drilling plug which are obstacles of well intervention. The salvaging type Non-plug-drilling tool eliminates the disadvantages of plug-drilling. By optimizing tool structure, improving technology, the reliability of salvaging type plug-drilling-free tool has been increased. More than 133 wells in 2012 had adopted the salvaging type plug-drilling-free tool with high reliability in Pai 601 Block of Xinjiang with 100% success rate.

**Key words:** Horizontal well; The salvaging type plug-drilling-free technology; Completion; Top screen cementing technology; Field application

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### INTRODUCTION

Horizontal well is the effective and efficient manner to improve oil field development. In recent years, top screen pipe cementing technology of casing in horizontal well has been one of the main well completion method<sup>[1]</sup>, running at about three-quarters of horizontal wells. However, main drawbacks of screen top cementing completion technology in horizontal wells are casing wear in the process of drilling plug and burrs in the inner surface after drilling plug which are obstacles of well intervention. For example, hardened cement paste of "A" target point is indeed prone to micro-fissure because of the bit vibration while drilling plug, which will cause channeling of oil gas and water or steam heat loss<sup>[2]</sup>. Casing wear in the process of drilling plug will reduce casing service life. The tool debris not only blocks circling tool on bottom but also influences the safely drip into design point. The development of salvaging type plug-drilling-free technology<sup>[3]</sup> avoids the process of drilling plug, which protects casing and hardened cement paste.

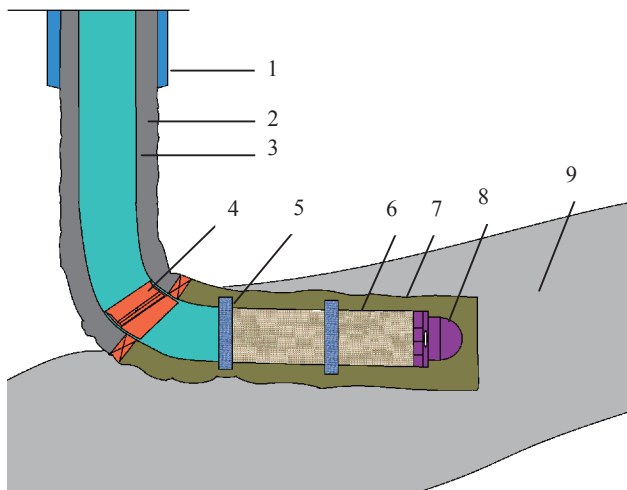
During 2008-2010, the salvaging type plug-drilling-free tool had been applied in more than 44 horizontal wells in Shengli Oilfield. At that time, there were many problems, such as exposed cement plug upping the tool, high uplift force, long-time milling and so on. Take wells of Xianhe Oil Production Plant for example, after cementing on the top of the sand control screen pipe for completion, the spear with the 3 1/2" drill pipe dripped into design point and fished the inner sleeve of tool. Fishing capacity was 400-600 kN on average which surpassed 100-200 kN. In view of the existing problems, tool structure improvement and measure of safeguard have been accomplished.

### 1. THE SALVAGING TYPE PLUG-DRILLING-FREE TECHNOLOGY

The salvaging type plug-drilling-free tool is developed with the function of external casing packer, stage collar

and blanking plate to avoid the damage to completion string during plug drilling.

As one of the relatively advanced sand control methods, open hole gravel pack technology for horizontal wells has been widely used in the world. So the completion string (from bottom to top) is guide shoe, gravel packing hookup, precise composite mental mesh screen, heat compensator, precise composite mental mesh screen, casing pipe (the length of this casing is generally 10-20 m), the salvaging type plug-drilling-free tool and casing pipe to wellhead (Figure 1). The role of gravel packing hookup is to ensure gravel packing outside the screen. And heat compensator has an important effect on relieving the thermal stress on the casing string of horizontal section. That is, the length of horizontal section is 150 m or less, one device is placed. If the horizontal section is longer than 150 m, then place one device every additional 100 m.



1.Surface Casing; 2.Hardened Cement Paste; 3.Casing; 4.The Salvaging Type Plug-Drilling-Free Tool; 5.Heat Compensator; 6.Screen Pipe; 7.Wellbore; 8.Gravel Packing Hookup; 9.Formation

**Figure 1**  
**The Casing String of Salvaging Type Plug-Drilling-Free Technology**

The process of salvaging type plug-drilling-free technology is similar to the traditional screen top cementing completion technology. Firstly, the pump starting pressure is 4-5 MPa in order to test pipeline pressure. The test pressure will not drop for 5 minutes of continuous operation. Then, the cementing truck produces 9 MPa to open the limited pressure valve of casing packer and boosts 10 MPa to inflate the compression packer. And, pressure rises to 16-18 MPa quickly by large cubic centimeters to open circulating valve for cementing. After cementing on top of the sand control screen for completion in this well, the pressure then continues increasing to 21-23 MPa (equal to hydrostatic fluid column pressure difference plus shearing-pin pressure) and maintains for 5 minutes to close the circulating valve. Finally, considering geological conditions of the well and

hydrostatic pressure, pressure waiting on cement setting shall drop to pressure value equal to hydrostatic fluid column pressure difference, which can prevent reverse flow of cement slurry.

According to the construction technology, the inner casing string is run in hole consisting of  $\Phi 152$  mm spear+ $\Phi 88.9$  mm drilling pipe to wellhead. When inner casing string drops into design point, firstly, hanging weight of casing string should be recorded that will be helpful for our judgement on whether or not to hang casing string. With lowering string, the hanging weight will reduce slowly until hanging weight reduces 10 t. Then pick up drill stem to the original depth and contrast the hanging weight difference between the recorded and the current. When the current weight is not more than recorded, it shows that inner sleeve has not been salvaged. On the contrary, it is successful to fish inner sleeve. Pull out of hole and drift to the casing bottom with the  $\Phi 152$  mm drill bit.

After cementing on top of the sand control screen for completion in this well, Mud cake acid cleanup process<sup>[4-5]</sup> is as follows: the cleanup string is connected with mud cake washing sealers, and bottom of the string connects with an inserting rod. By coordination of the washing sealing device and the screen pipes, the inserting rod and flushing valve will change the flowing direction of the fluid, establishing circulation between the outer pipe and the inner pipe to clean up the borehole wall. By considering the length of horizontal section and optimizing the number of the mud cake cleanup sealing devices, mature filed operating programs have been formed, that is, the length of horizontal section is 150 m or less, one mud cake cleanup sealing device is placed every 30 m. If the horizontal section is longer than 150 m, then place one device every additional 50 m. After acid is pumped into place, soak for 40 minutes. The pump starting pressure for reverse acid cleanup is 5-6 MPa (If the primary cake washing sealer is used, acid cleanup pressure is generally 2-3 MPa). The acid cleanup pressure maintains for 40 minutes of continuous operation. Thick mud returns at the wellhead, showing that acid cleanup result is excellent.

## 2. THE FEATURES OF THE SALVAGING TYPE PLUG-DRILLING-FREE TOOL

### 2.1 Structure of the Salvaging Type Plug-Drilling-Free Tool

Figure 2 shows the structure of the inner tube Fishing Non-plug-drilling tool of foreign company<sup>[6-7]</sup>. This kind of tool concludes inner tube packer, cementing assembly, Packer assembly, Camp. The benefits of this structure are:

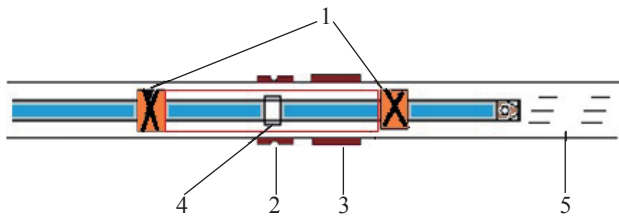
(1) No drill out: The tool is full-bore whether it is operated or not.

(2) Premium thread or weld on connector options readily available.

(3) Selective operation allows the use of multiple tool in a completion assembly.

(4) Metal-to-metal seals.

However, by using a clamp to close the cementing switch, this structure could not determine the closure at the wellhead, and it need pulling, rotation, pressure test repeatedly to judge whether or not cementing switch close. Technological success rate is low. A simple (up/down or rotate) movement of the inner tube repeatedly will wear the inner tube packer, cement leakage into the screen even set, have big construction risks called “stick the flagstick”.



1-Inner Tube Packer; 2-Cementing Assembly; 3-Packer Assembly; 4-Camp; 5-Screen

**Figure 2**  
**The Inner Tube Fishing Non-Plug-Drilling Tool**

By contrast, the fishing non-plug-drilling tool is consisted of four parts: cementing assembly, packer

**Table 1**  
**The Performance Parameters of Tool**

| Tool                    | OD, min | ID after Salvaged, mm | Sealing pressure of packer, MPa | Closing pressure of packer, MPa | Opening pressure of cementing assembly, MPa | Closing pressure of cementing assembly, MPa |
|-------------------------|---------|-----------------------|---------------------------------|---------------------------------|---------------------------------------------|---------------------------------------------|
| Plug-drilling-free Tool | 212     | 155                   | 9                               | 10                              | 16-18                                       | 5                                           |

The rubber inflate system and the cementing cycle channel on-off system are non-interference each other, which could avoid soldering the fishing parts by slurry. It will increase the reliability of shut off plug. Change the outside seal ring from O-type ring to T-type ring, which avoids seal rings dropping into well when fishing. Add the function of closing piston limit in order to ensure cementing work on track. Intensify the seal system that will guarantee the reliability at high temperature and pressure.

The drillability of accessories of the salvaging type plug-drilling-free tool is mainly due to its material using the experience of the processing stage cementer requirements of cementing. The internal accessories are made of aluminum alloy or rubber basically. Aluminum alloy is accounted for a large proportion. So the aluminum alloy drill ability is the most important factor which influences the time of the overall drill accessories. At present, there are two kinds of aluminum alloys: cast aluminum alloys and hard aluminum alloys. According to the experiments of drillability<sup>[8]</sup> and the requirements

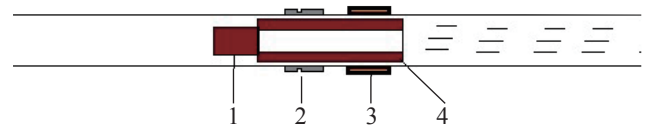
assembly, tieback canister and the inner sleeve system. They are the critical components of screen top cementing completion technology (Figure 3). Table 1 shows the performance parameters of tool. This tool combines features of external packer, stage cementer, blind plate, constructed into the well with completion columns. The effect is to close off the producing reservoirs, build cementing channel, and prevent screen pollution by cement. The advantages are:

(1) Simple and reliable structure design. It needs to salvage by spear instead of drilling out. Compared to the inner tool, this design has the advantage of less risk.

(2) Without grouting. Ball seat on the bottom of tool establishes the connection of casing pipe and the external annulus. It needn't grout, so the advantage is prevent opening the cementing tool prematurely by high pressure difference on casing process.

(3) No change construction procedure. The procedure is similar to the cementing on the top of screen.

(4) No rotate to release.



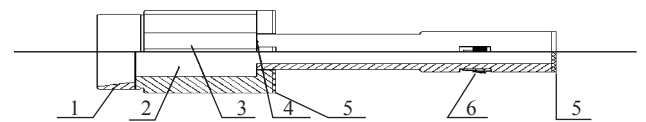
1-Tieback Canister; 2-Cementing Assembly; 3-Packer Assembly; 4-Inner Sleeve System

**Figure 3**  
**Fishing Non-Plug-Drilling Tool**

of tool processing, the internal accessories select hard aluminum alloys.

## 2.2 Structure of the Spear

The structure of the spear has the function of drilling plug and salvaging the inner sleeve system (Figure 4). The spear OD is  $\Phi 152$  mm. If the inner sleeve system cannot be salvaged successfully, the mill shoe can rapidly drill and rush to the cylinder upper residual cement of the tieback canister. At the same time, the bottom part of mill shoe can be used as inserting rod easily entering the tieback canister. The distribution of circumferential spear slider in the inserted rod increases the rate of successful of fishing.



1-Female Thread; 2-Inner Channel; 3-Flute; 4-Flushing Port; 5-Mill Shoe Tungsten Carbide Insert; 6-Slider

**Figure 4**  
**Spear**

### 2.3 The Improvement of Technology

#### (1) Waiting on cement setting

Pressure waiting on cement setting is mainly deal with the situation that the emission have already exceeded the calculated value in the conventional cementing, but still don't touch the condition of pressure capsule. In the salvaging type plug-drilling-free completion technology, the artificial implementation of pressure waiting on cement setting can prevent the cement slurry leakage on the upper plug effectively. The time and pressure depend on specific circumstances.

#### (2) Addition of retarder

In the precondition of not influencing the liquid separation performance, the addition of retarded can alleviate the tieback canister near residual cement setting effectively. It saves a lot of time for salvage operation.

(3) Change the rubber stopper free into the suction casing to pad fluid displacement entering

At present, the rubber stopper is placed in well cementing device. When the end of the cement work and the start of replacement, the rubber stopper is free to get into the suction tube after the switch is opened. Because of the operation of construction, it will cause the situation that there is no upper fluid in the rubber stopper during certain period of time, the possibility of rubber stopper deflection is bigger. Therefore, this change can avoid the situation the no upper fluid in the process of pump.

(4) Raise the pressure from 14MPa to 16 MPa of cementing assembly. This change creates more pressure difference from packer inflate pressure (10-12 MPa). It's convenient for operation and control.

### 3. FIELD APPLICATIONS

Pai 601 Block in the west of Junggar Basin Xinjiang, Tectonic location Located in the western Junggar basin Red Car fault zone top of the eastern Chepaizi uplift. Area belongs to the lower-level structural entities of West uplift Junggar Basin. This block uses horizontal wells to develop Tsuchiya Ru group in the Cretaceous. It's a shallow super heavy oil reservoir and loosen lithology. Vertical depth is 500 m. Design of horizontal well's vertical ratio is 1:1. The completion is screen top cementing completion technology. And steam huff and puff can maximize the productivity advantages.

In order to protect casing or improve the completion quality, the salvaging type plug-drilling-free tool had been implemented on screen top cementing completion technology. In 2012, there were 133 horizontal wells that adopted this technology. The test showed that tool performance was stable, with 100% success rate.

Take Pai 601-P225 Well for an example, this well had been constructed in May, 2012. Because of loosely lithological character and bigger completion accessories' size, the tripping of casing became difficult. The well head load became 0 t even, which need add 20 t assisting press by wellhead pressure device. In this situation, the salvaging type plug-drilling-free tool still opened properly (17 MPa) and fished successfully (uplift force 15t), emphatically verified the reliability of tool.

### CONCLUSION

(1) The salvaging type plug-drilling-free tool overcomes the drawbacks of screen top cementing completion technology.

(2) By optimizing tool structure, improving technology, the reliability of salvaging type plug-drilling-free tool has been increased.

(3) The field test of Pai 601 Block shows that the tool has reasonable structure, reliable performance and higher success rate of salvaging.

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