

# Application of combined test string of RD bypass pressure test valve and RD safety circulation valve

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**Abstract.** At present, in the test construction of high temperature, high pressure and high hydrogen sulfide wells, in order to simplify the pipe string structure and improve the process success rate, the combination of RD safety circulation valve and OMNI multiple circulation valve is often used to carry out the triple operation of perforation+acid fracturing+test, which can realize the operation of one opening and one closing. However, due to the complex structure, high failure rate and high construction cost of the OMNI multi-cycle valve, most operators are unwilling to use it, but without the pipe string of the OMNI multi-cycle valve, the slurry replacement operation cannot be completed. This paper introduces an RD bypass pressure test valve which can replace OMNI multi-cycle valve. It can not only realize the function of slurry replacement, but also increase the success rate of operation because of its simple structure, so it is more and more favored by users.

**Key words:** Hydrogen sulfide, test, RD safety circulation valve, Omni multiple circulation valve, RD bypass pressure test valve

## 1. Introduction

APR test tool is a full-bore test tool produced by Halliburton Company in the United States. Since its core components including test valve, circulation valve and sampler are all switched and operated through annular pressure and pressure relief, so Simple to operate, it has become a widely used tool in the field of formation testing (DST). In the past ten years, in the domestic high temperature, high pressure and high hydrogen sulfide well testing construction, considering the need to simplify the pipe string structure and improve the success rate of the test process, the test valve is generally no longer used, but the RD safety circulation valve is used. It is used as a shut-in valve, while the OMNI multi-circulation valve is used to complete the slurry replacement operation before the test. However, for deep wells and ultra-deep wells with high mud weight, it is difficult to operate the OMNI multi-cycle valve for transposition because of the large pressure difference between annulus and pipe string after slurry replacement, which often leads to the failure of the OMNI multi-cycle valve and the test failure. Therefore, the use of the OMNI multi-cycle valve has been gradually cancelled in some pipe strings. Only RD safety circulating valve and RD circulating valve are used as test valve and circulating valve, but this kind of string can't complete slurry replacement operation, and the string function is missing. Especially when the target layer has been opened, there is a risk of well control.

Rd bypass pressure test valve is a test tool with the opposite function to RD safety circulation valve, which

can well replace Omni multiple circulation valve to achieve the purpose of slurry replacement. Because of its simple structure and high operation success rate, it has been applied in the test and construction of more and more high-temperature, high-pressure and high hydrogen sulfide wells.

## 2. Analysis of the advantages and disadvantages of different pipe string types

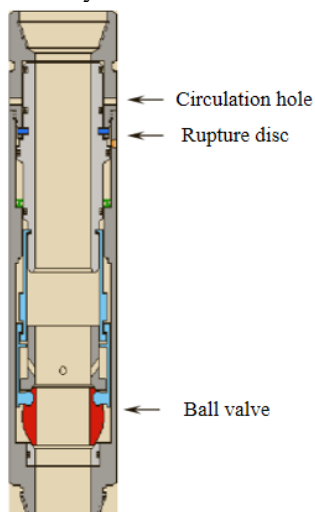
### 2.1 Traditional test string

In the traditional APR test string, LPR-N test valve, as the main test valve, can be operated by the annular pressure to realize multiple downhole opening and closing. However, because LPR-N test valve has nitrogen chamber and oil chamber, many sealing points and complex structure, the failure rate is relatively high in "three high" (high temperature, high pressure and high hydrogen sulfide content) well test, and LPR-N is expensive. Therefore, it has been rarely used in "three high" wells, especially in gas well testing. Instead, use the RD safety circulation valve.

### 2.2 Combined string of RD safety circulation valve and omni multiple circulation valve

The RD safety circulating valve (see Figure 1) was originally designed as a circulating valve. After the test, the annulus is pressurized to the designed pressure value

to break the splitting disk, cut the pin, move the mandrel down, open the circulation valve hole, and close the ball valve, so that the oil sleeve can be connected and circulated. At the same time, the ball valve is closed, which blocks the upward return of formation fluid and plays the role of safety valve.



**Figure 1** The upward return of formation fluid and plays the role of safety valve.

At present, the RD safety circulation valve is commonly used in conjunction with the OMNI multiple circulation valve in the current "three-high" wells. After the packer is set, the slurry can be replaced first, then tested, and then the RD safety circulation valve can be opened to realize the purpose of shutting in the well.

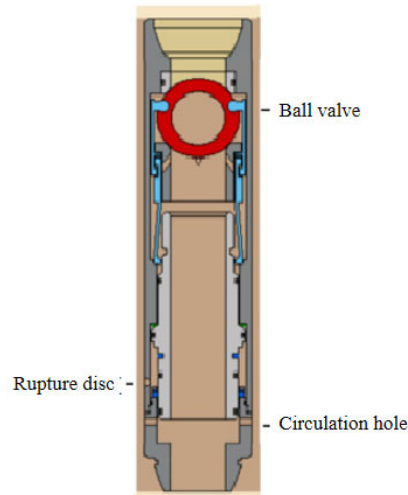
The combination of RD safety circulation valve and omni multiple circulation valve can realize negative pressure through slurry displacement before test, and can complete the test of one opening and one closing at the same time. However, as Omni multiple circulation valve is similar to LPR-N test valve, it also includes nitrogen chamber and oil chamber, and its structure is more complex than LPR-N test valve. In particular, its transposition mechanism is very easy to be blocked and unable to realize tool operation under the condition of more mud sediment, or the ball valve cannot be opened because the upper and lower pressure difference of the ball valve is too large after slurry replacement, Therefore, the operation failure rate of Omni multiple circulation valve is higher.

### 2.3 RD Safety Circulation Valve and RD Circulation Valve Combination String

The function of this string is similar to that of the combination string of RD safety circulation valve and +OMNI circulation valve, and once downhole shut-in can be realized by using RD safety circulation valve as shut-in valve. Since RD can only be operated once, the pulp replacement before acid fracturing can not be realized. However, because there is no oil chamber or nitrogen chamber in RD safety circulating valve and RD circulating valve, the tool stability is strong, the construction success rate is high, the cost is low and the economic benefit is good.

### 2.4 Combined string of bypass pressure test valve (positive installation) and RD safety circulation valve

The bypass pressure test valve (see Figure 2) is developed according to the structural principle of the RD safety circulation valve, and its function is just the opposite of the RD safety circulation valve.



**Figure 2** The opposite of the RD safety circulation valve.

In the running process of conventional well test, the bypass pressure test valve is going down, the ball valve is in the closed state, and the circulation hole is in the open state, which can balance the pressure inside and outside the pipe string and facilitate the packer running. After the packer is set, the cracked disc is broken by annular pressure, the pin is cut, the mandrel is moved down, the ball valve is opened and the circulating valve hole is closed for testing. By using the combination of bypass pressure test valve and RD safety circulation valve, the annulus pressure can be operated after the test, the circulation hole of RD safety circulation valve can be opened, and the ball valve can be closed, so as to realize a downhole shut in. At the same time, the oil jacket above the ball valve is connected, and the space above the ball valve can be circulated.

### 2.5 Combined pipe string of bypass pressure test valve (reverse installation) and RD safety circulation valve

In the process of "three highs" well test, the bypass pressure test valve is inverted into the well, the circulation hole is in the open state, and the ball valve is in the closed state. After the packer is set, the slurry can be replaced by the circulating hole to realize negative pressure, and then the annular pressure is increased to the designed pressure value to break the splitting disk, cut the pin, move the mandrel up, close the circulating valve hole and open the ball valve for testing. Similarly, by using the combination of bypass pressure test valve and RD safety circulation valve, after the test, the annular pressure can be operated, the circulation hole of RD safety circulation valve can be opened, and the ball valve can be closed, so as to realize one-time downhole shut-in. At the same time, the oil

sleeve above the ball valve is connected, and the space above the ball valve can be circulated.

In the triple operation of TCP perforation + DST test + acid fracturing, the bypass pressure test valve can also be installed upside down, the circulating hole is on, and the ball valve is off. After the packer is set, the original liquid in the string is replaced by acid fracturing working fluid to avoid the original liquid being pressed into the formation. Then, the split disc is broken by pressurizing the annulus to the designed pressure value, the pin is cut off, the mandrel moves upward, the circulating valve hole is closed, and the ball valve is opened, so that acid pressure operation can be carried out, and then flowback and test can be carried out. After the test, operate the annulus pressure, open the circulation hole of RD safety circulation valve, and close the ball valve, so as to realize a downhole shut in. At the same time, the oil jacket above the ball valve is connected, and the space above the ball valve can be circulated.

Because the bypass pressure test valve and the RD safety circulation valve are similar, the structure is simple, the sealing points are few, and there is no complicated structure such as nitrogen chamber and oil chamber, so it is easy to operate and has a very low failure rate, especially with the addition of an RD circulation valve. The use of the device can basically ensure the realization of the one-on-one-off operation function and the well control safety of the test process, especially to meet the requirements of "three-high" wells with simple structure, convenient operation and high success rate.

**Table 1** Comparison of advantages and disadvantages of various tool combination strings

Serial number	Type of pipe string	String structure	Advantage	Disadvantage
1	Traditional APR string	Rd safety circulation valve + Omni multiple circulation valve + LPR-N test valve + RTTS packer	Meet the needs of slurry replacement, negative pressure, and multiple downhole well switching	There are many sealing points and complex structures, especially the OMNI multi-cycle valve and LPR-N test valve, which have complex structures and high failure rate, and are not suitable for the simple and efficient requirements of "three high" wells for test strings. High construction cost
2	Combination string of RD safety circulating valve and OMNI circulating valve	Rd safety circulation valve + Omni multiple circulation valve +	It can meet the requirements of slurry replacement and negative pressure, and can use	There are many sealing points, complicated structure, complicated structure of OMNI

		RTTS packer	the RD safety circulation valve to realize one-time shut-in. The structure of the pipe string is simpler than that of the traditional APR pipe string.	multi-cycle valve and high failure rate; It is impossible to open and close the well underground for many times; Higher construction cost
3	Combination string of RD safety circulating valve and RD circulating valve	Rd circulation valve + Rd safety circulation valve + RTTS packer	The pipe string is the simplest, and the RD safety circulation valve can be used to realize one-time shut-in, and the construction cost is low	If slurry can't be replaced, all the liquid in the pipe string should be pressed into the formation during acid fracturing, which increases the difficulty of drainage. It is impossible to open and close the well underground for many times.
4	Combination string of bypass pressure test valve (front) and RD safety circulation valve	Bypass pressure test valve (front mounted) + Rd safety circulation valve + RTTS packer	The pipe string is simple, the pipe string above the ball valve can be tested for pressure during the downhole process, and the RD safety circulation valve can be used to realize one-time shut-in, and the construction cost is low	If slurry can't be replaced, all the liquid in the pipe string should be pressed into the formation during acid fracturing, which increases the difficulty of drainage. It is impossible to open and close the well underground for many times.
5	Combination string of bypass pressure test valve (reverse installation) and RD safety circulation valve	Bypass pressure test valve (reverse installation) + Rd safety circulation valve + RTTS packer	Meet the requirements of slurry replacement and negative pressure, and use the RD safety circulation valve to realize one-time shut-in, and the construction cost is low	It is impossible to open and close the well underground for many times.

### 3. Application examples

The Hari-6 well in the Nanjiangbi block of Gemdale Corporation in Indonesia was constructed by the DST test team of the Indonesian Project Department and the acid

fracturing construction. A total of 2 layers were completed, and the construction was carried out according to the following scheme.

Construction scheme: bypass pressure test valve (reverse installation)+RDS valve+lower RD valve +RTTS packer

The specific construction steps are as follows:

①Down into the test string: oil pipe + bypass pressure test valve (reversely installed, that is, the circulation hole is on the top and the ball valve is on the bottom) + RDS valve + lower RD valve + RTTS packer + oil pipe;

②Set RTTS packer;

③ Use 1.02g/cm<sup>3</sup> base slurry to replace 1.25g/cm<sup>3</sup> slurry through the bypass hole of the bypass pressure test valve;

④Close the tubing at the wellhead, pressurize from the annulus, operate the bypass pressure test valve to close the bypass hole, and open the ball valve (the ball valve can withstand a pressure difference of 105MPa and is easy to open);

⑤ Carry out acid fracturing operation and drainage for production;

⑥ After the production is completed, pressurize the annular space, operate the RDS to open the circulation hole, close the ball valve, and then the pressure recovery test can be carried out. At the same time, the mud circulation of 1.25 g/cm<sup>3</sup> is carried out on the space above the ball valve. If the RDS operation fails, the lower RD valve can be opened. Circulation hole for 1.25g/cm<sup>3</sup> mud circulation).

## 4. Conclusion

The advantage of the OMNI circulation valve is that it comes with a ball valve, and the circulation valve can be switched on and off infinitely without limit, but its complex internal structure, cumbersome operation links, and high maintenance costs have been criticized by users. With the increase of high temperature, high pressure wells and acid fracturing wells, the working stability of the internal oil and gas chamber structure is also greatly affected under complex working conditions. Although the RD bypass pressure test valve has a single function, it has simple structure, easy operation, and the tool stability is less affected by well conditions. At the same time, it can be used flexibly, and can be used in good compatibility with RD and RDS. It can basically realize the role of Omni in construction, achieve better construction effect and achieve higher construction success rate.

## References

1. Qin Jishun, Li Aifen. Reservoir physics [M], Shandong: China University of Petroleum Press, 2006: 66-80
2. Li Bo, Luo xianbo, Liu Ying et al. A new method for determining interlayer heterogeneity [J]. Offshore oil and gas, China, 2007,19 (2) 93-95
3. J.Tingas,M.Greaves,T.J.Young,Field Scale Simulation Study of In-situ Combustion in High Pressure Light Oil Reservoirs.Presented at the

SPE/DOE Improved oil Recovery Symposium,Tulsa,Oklahoma,21-24 April,1996,SPE-35395-MS.

4. Ji Bingyu,Li Yan xing. Main Technical Countermeasures of Enhanced Oil Recovery during High Water Cut Stage in La-Sa-Xing Reservoirs [J]. Petroleum Geology&Oil field Development In Daqing,2004,23(5):94~95
5. B.F.DemblaDhiraj,Simulating Enhanced Oil Recovery(EOR)by High-pressure Air Injection(HPAI)in West Texas Light Oil Reservoir,Msc.Thesis,The University of Texas at Austin,2004.