Small Diameter Dobby Multi-arm Caliper and Electromagnetic Defect Detection Combined Logging for Evaluation Quality of Deep Gas Well Casing

Gao Ming

Daqing Oilfiled Logging and Testing Technology Co., Daqing, Heilongjiang, 163153, China

Keywords: deep gas well, casing quality, multi-arm caliper logging tool, electromagnetic detection logging tool

Abstract: In order to guarantee the smooth progress of the deep gas well fracturing and subsequent development must be qualitative and quantitative evaluation of the deep gas well casing quality, this paper puts forward the small diameter dobby multi-arm caliper and electromagnetic defect detection combined logging technology scheme for deep gas well casing quality evaluation, by using this scheme for A1 Well, A2 Well and A3 well downhole testing and anticorrosive 13Cr casing pipe surface test. The test results show that there are the small diameter dobby multi-arm caliper and electromagnetic defect detection combined logging for deep gas well casing quality detection technology that can be judged, downhole casing degree of risk, for gas recovery branch fracturing, well completion, workover, and provide a reliable basis for the establishment of perforation scheme.

1. Introduction

The oil and gas equivalent of a certain oilfield continues to be sTable, and large-scale fracturing has become the main means of tapping the production capacity of the gas well. However, the damage and leakage of the casing directly affect the fracturing effect and subsequent capacity of the gas well. Therefore, the casing quality evaluation extends the service life of the casing. It is of great significance to improve the economic benefits of oilfield development. At present, oil wells generally use multi-arm caliper to evaluate casing quality [1], and water wells use electromagnetic flaw detection tools to evaluate oil and casing quality [2]. For the evaluation of deep gas well casing quality, use multi-arm caliper Or an electromagnetic flaw detection tool?

2. Technical scheme of casing quality evaluation for deep gas well

2.1 Deep gas well characteristics

It can be seen from Table 1 that the depth of a deep gas well in an oil field is more than 3000m, which determines the characteristics of high-temperature and high-pressure in deep gas wells. The stratigraphic pressure of the deep gas well block is between 37.48-43.33MPa, and the average measured formation pressure is 38.23MPa. The pressure coefficient is 0.96/100m to 1.11MPa/100m. The measured temperature of the formation in the deep gas well block is between 125.6 ° C and 162.4 ° C, and the temperature gradient is between 3.8 ° C / 100 m and 4.34 ° C / 100 m. The selection of logging instruments must take into account this objective condition, and the temperature and pressure resistance indicators and signal transmission methods of the instrument are the primary conditions. The principle is that the temperature resistance index of the instrument is greater than the actual temperature of the formation, and the pressure resistance index is 1.2 to 1.4 times of the formation pressure. That is, the instrument selects the high temperature and high pressure resistant instrument, combined with the current instrument index, the instrument temperature resistance index is 175 ° C, and the pressure resistance index is 80 MPa. . At the same time, in order to prevent blowout and oil and gas leakage, a high-pressure sealed blowout preventer with a pressure of 70 MPa is used. According to the signal transmission mode of the well logging tool, the telemetry method must be selected. The pulse mode cannot transmit the ground through the logging cable after the well depth exceeds 3000m. Therefore, the Manchester code transmission mode is selected.

It can be seen from Table 2 that the gas in the deep gas well has a corrosive gas CO_2 and a small amount of H_2S, which requires that the high pressure sealed blowout preventer and the downhole instrument must be corrosion resistant. It has been shown in the literature that Cr-containing steel can effectively reduce CO_2 corrosion [3], 17-4PH alloy steel consists of copper, tantalum/niobium precipitated, hardened, martensitic stainless steel. After heat treatment [4], the mechanical properties of the product are more perfect. It can reach pressure resistance up to 1100-1300 MPa and high temperature of 300 °C [5]. It has good corrosion resistance to H2S. At present, 17-4PH alloy steel is widely used in downhole instruments to ensure that the downhole equipment is not corrosive. Corrosion of CO_2 and H_2S.

Table 1 Completion data of a gas well in an oil field

Name	Specification	Steel grade	Wall thickness (mm)	Inner diameter (mm)	Depth(m)	Cement back depth (m)
Surface casing	339.7	J55	9.65	317.6	299.18	Ground
Technical casing	244.5	P110	11.05	222.40	3250.11	Ground
Reservoir casing	139.7	P110-13Cr/P110	9.17	121.36	10.37~3876.20	Ground
	139.7	P110	P110	121.39	3876.20~5366.20	Unfilled well below 3000

Table 2 Table of natural gas components in a well area of an oil field

Component	methane	ethane	propane	N_2	CO_2	Remarks
Percentage (%)	81.8-94.79	0-3.06	0-1.77	0-7.82	1.41-9.99	Before pressing
Average (%)	89.76	1.93	0.36	2.26	5.2	

2.2 Advantages and disadvantages of multi-arm caliper and electromagnetic flaw detection tool

The multi-arm caliper judges the damage of the downhole pipe string by the contact between the measuring arm and the inner wall of the pipe string. The mechanical structure determines the outer diameter of the mechanical assembly, such as the 16-arm caliper and the 36-arm caliper outer diameter produced by the test company. 70mm, 40-arm caliper outer diameter 73mm, Xi'an Sitan's three-arm caliper, XY caliper and 24-arm caliper outer diameter 43mm, 40-arm caliper 70mm, 60-arm caliper outer diameter 100mm. The inner diameter of the 139.7mm production casing ranges from 121.4mm to 127.3mm, and the length of the multi-arm caliper is generally greater than 2m. When the casing has deformation or high inclination well, the 36-arm caliper, 40-arm caliper, The 60-arm caliper is difficult to enter, and under the premise of ensuring the smooth entry of the multi-arm caliper, it is necessary to ensure that the logging data is comprehensively selected from the small-diameter 24-arm caliper produced by Xi'an Sitan. At the same time, the mechanical structure of the multi-arm caliper determines that when there is foreign matter, wax formation and the measuring arm is scraped off, the logging will be distorted; the measuring arm contact measurement can not detect the thickness of the column, the lateral and longitudinal cracks, and the small diameter electromagnetic The flaw detection tool (outer diameter 40mm or 42mm) uses the low-frequency eddy current detection technology to make up for the defects of the multi-arm caliper, so the combination of the two can comprehensively analyze the working condition of the downhole string [6].

By analyzing the characteristics of deep gas wells and the advantages and disadvantages of multi-arm caliper and electromagnetic flaw detection tools, the quality evaluation of deep gas well casings uses a combination of small-diameter multi-arm caliper and electromagnetic flaw detection.

3. Field Application of Small Diameter Dobby Diameter and Electromagnetic Flaw Detection Logging Technology

Through the comprehensive analysis of the small-diameter multi-arm caliper and electromagnetic flaw detection logging technology in the three-hole deep gas well casing quality inspection data of A1, A2 and A3, the problems of different quality of the casing are found, which is recognized by Party A. Provide a reliable basis for the development of its next steps.

3.1 A1 well casing quality inspection application

Well A1 is a horizontal gas well developed in X gas field to be put into operation. After the process of reconstitution of the soluble bridge plug perforation, the well is unsealed after the first stage bridge plug is unsealed. Deepening the salvage bridge plug pipe column and the lower reverse circulation salvage pipe string encounter resistance, the lead die, the results show that the resistance may be casing fracture, in order to determine the condition of the downhole casing, small diameter multi-arm caliper and electromagnetic flaw detection logging .

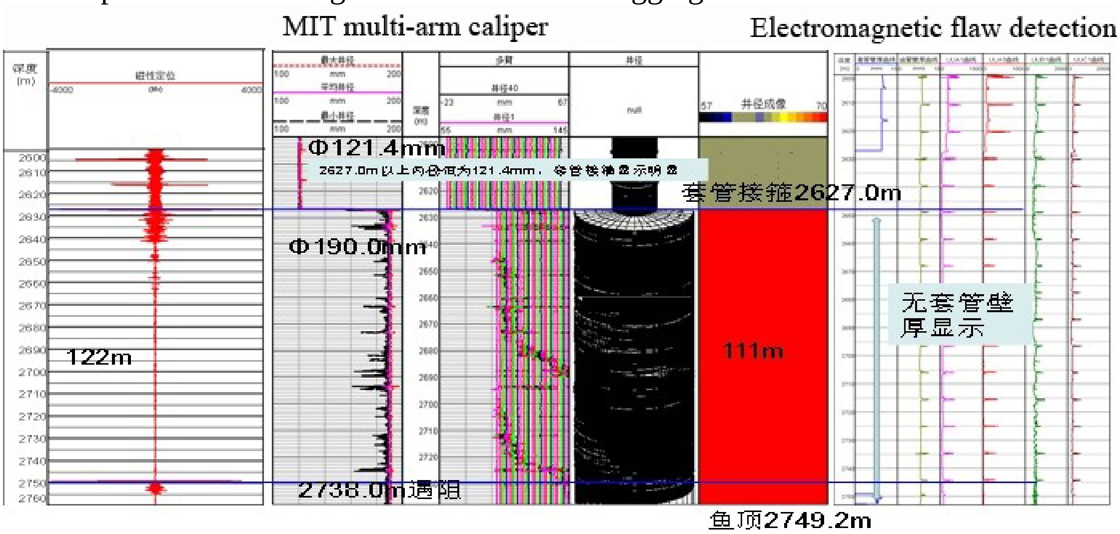


Figure 1 A1 well logging results

3.2 A2 well casing quality inspection application

The A2 well is planned to carry out the transformation of the cable pumped soluble bridge plug perforation fracturing process. In November 2017, the tool was blocked during the first-stage bridge plugging process. The depth of resistance was 2,531m. The cable was connected to the φ114mm lead die for printing. The outer diameter of the largest mark was found to be φ110mm. There were 3 obvious marks. The well was large. The quality of the casing was not tested before the fracturing, resulting in serious leakage during the fracturing process and the fracturing scheme could not be continued. In view of this situation, in order to understand the real condition of the casing in the well, small-diameter multi-arm caliper and electromagnetic flaw detection logging are carried out, and the risk degree of the downhole casing is judged according to the logging result, which provides a basis for the subsequent scheme formulation.

(1) Casing deformation

As shown in Fig. 2, the 2530-2532m caliper logging curve is abnormal, and the 2530-2532m multiple probe curves are abnormal, which is interpreted as casing damage, and the well temperature curve shows low temperature anomaly, which is analyzed as casing leakage or formation low temperature anomaly zone. The minimum caliper value at 2531.3m is 118.09mm, and the maximum caliper value is 144.38mm. The 2518.8-2528.7m caliper log and electromagnetic flaw detection curve are abnormal, which is interpreted as slight deformation of the casing. The minimum caliper value is 119.76mm. The maximum caliper value is 123.49 mm. Through the comprehensive interpretation analysis of small diameter multi-arm caliper and electromagnetic flaw detection logging data, it is judged that the 2530-2532m casing is seriously damaged and leaked, and it is impossible to carry out the cable pumping of the soluble bridge plug perforation fracturing process transformation according to the original plan. Party A changed the fracturing method according to the results of the casing quality test, and finally completed the well by the pipe conveying perforation.

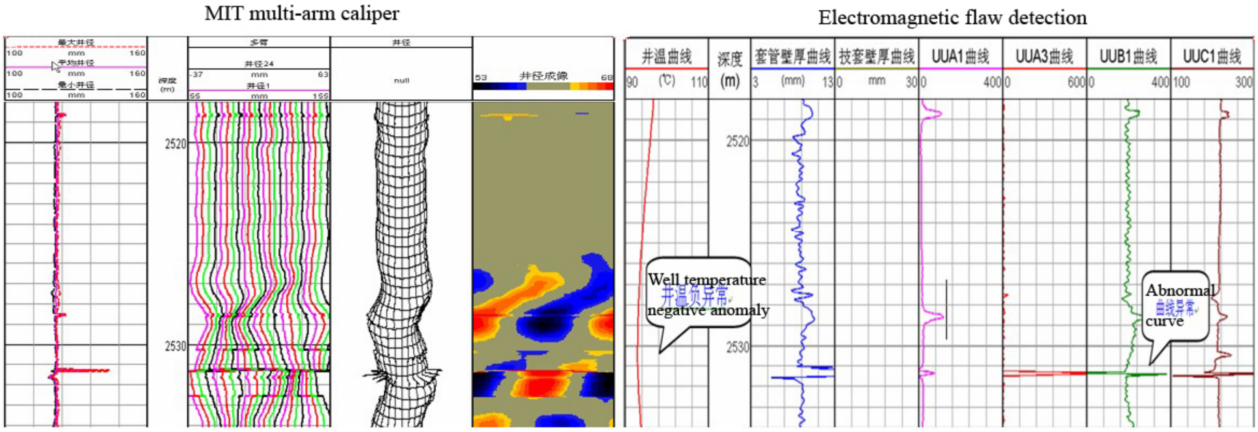


Figure 2 A2 well 2518-2534m multi-arm caliper and electromagnetic flaw detection log interpretation results

(2) Casing elliptical deformation

As shown in Figure 3, the well logging curve of the A2 well shows that the largest, smallest, and average well diameter dispersion phenomenon occurs in the casing sections of about 10m, such as 1273-1283.1m, 3463.1-3473.5m, etc.

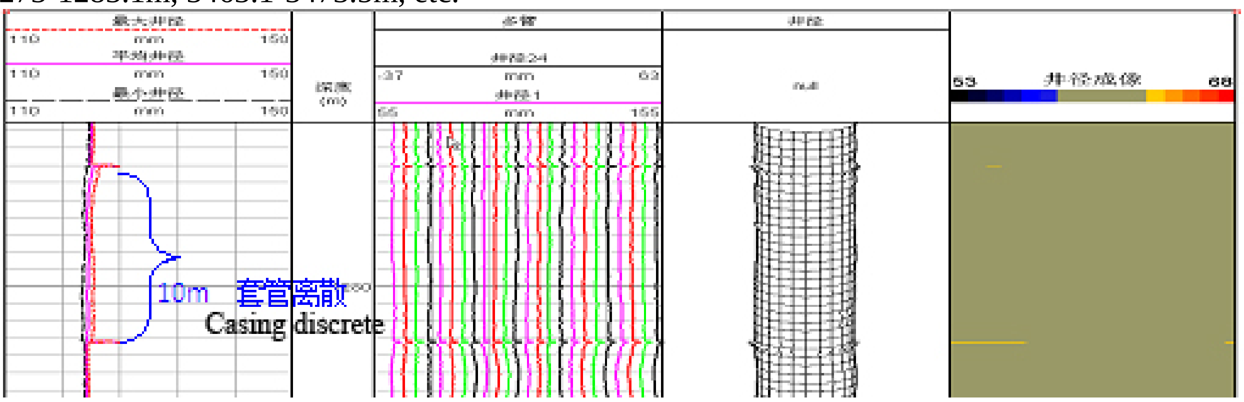


Figure 3 A2 well 1273-1283.1m multi-arm caliper logging interpretation results

(3) Slight damage to the casing

The multi-arm caliper logging curve shows that the well diameter becomes larger at 28m, 71m, 3128.4m, etc. The electromagnetic flaw detection log shows that there are many places in 2499-2507m, 2823.0-2834.4m, 3540.6-3550.7m, etc. Abnormalities are all explained as mild damage to the cannula. Statistical analysis of multi-arm caliper and electromagnetic flaw detection logging data, the casing has a slight damage of up to 28, indicating that there is a quality problem in the 13Cr casing of the whole well anti-corrosion, and there is a very high risk for the fracturing transformation of the various layers in the later stage.

(4) Anti-corrosion 13Cr pipe material has a small magnetic permeability

As shown in Fig. 4, the electromagnetic flaw detection log shows that the probe curve of the outer tube is abnormal near 2499m, which is explained by the end of the outer casing, and the well condition is changed from double pipe to single layer pipe. In the case of a normal double-layer tube, the response amplitude of the inner tube coupling is greater than that of the outer tube, and the coupling amplitude of the well is opposite, and the inner tube coupling is low, indicating that the magnetic permeability of the 13Cr tube is small, the outer layer The tube coupling has a high amplitude, indicating that the magnetic permeability of the outer tube is normal.

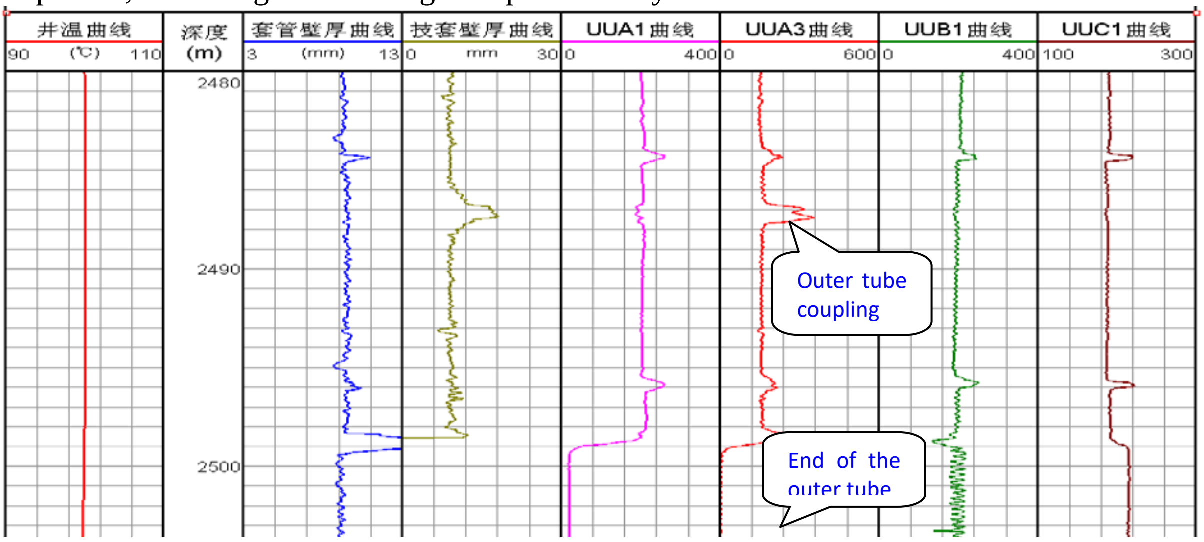


Figure 4 A2 well 2480-2504m electromagnetic flaw detection logging interpretation results

3.3 A3 well casing detection technology application

Based on the casing problems of the above two wells, before the A3 well fracturing process is reformed, Party A requires full casing inspection. Figure 5 below shows some of the measurements.

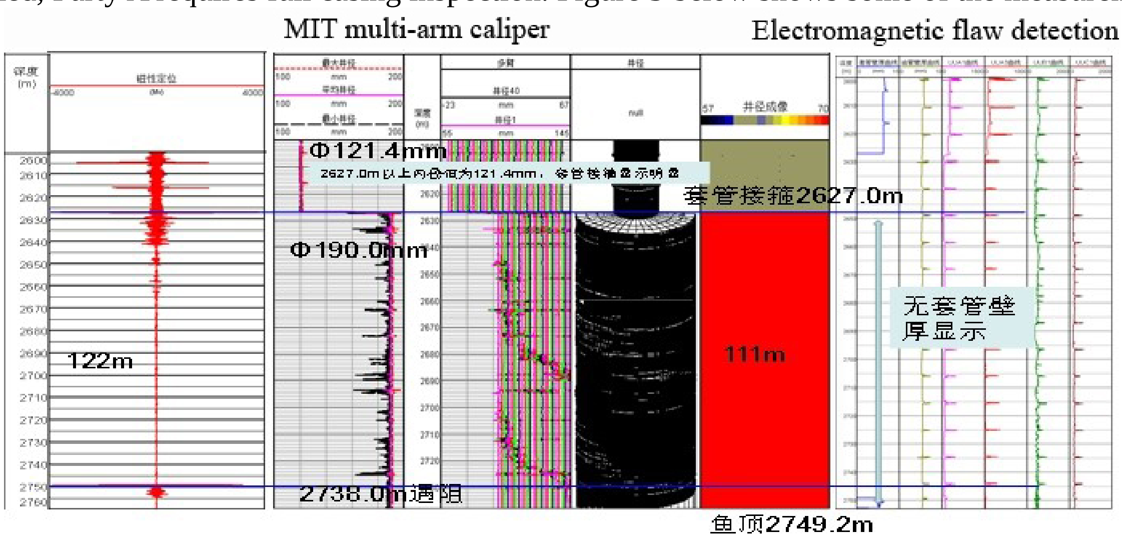


Figure 5 A3 well multi-arm and electromagnetic flaw detection data results

Through the whole well logging data, almost every casing has two anomalies, which are located 2.5 to 4 meters above and below the coupling, and the multi-arm caliper and electromagnetic flaw detection log curves are obvious, indicating the whole well anti-corrosion. There is a quality problem with the 13Cr bushing. This problem has extremely high risk for post-fracture modification. It is strongly recommended that Party A select 13Cr casing for ground inspection to avoid the risk of casing rupture during fracturing.

3.4 Anti-corrosion 13Cr casing ground test field test

Party A adopts the suggestion of data interpretation to conduct small-diameter multi-arm caliper and electromagnetic flaw detection on the ground for anti-corrosion 13Cr casing. As shown in Fig. 6 and Fig. 7, the two logging curves of No. 275 and 159 produced by B manufacturer are abnormal, and there are quality problems; as shown in Fig. 8, the number No. 101 produced by B manufacturer and the number 251 produced by C manufacturer are three. The casing logging curve is normal and there are no quality problems.

According to the ground test results, the following suggestions are proposed for Party A: investigate the manufacturer's production process, determine whether the casing processing results are different due to different casing processing methods or other special processes; use the ground casing detection means for the seed casing The tube is tested to determine whether it is normal; the casing is dissected, the inside of the tube wall is observed, and the material of the casing and the consistency of the test data are verified.

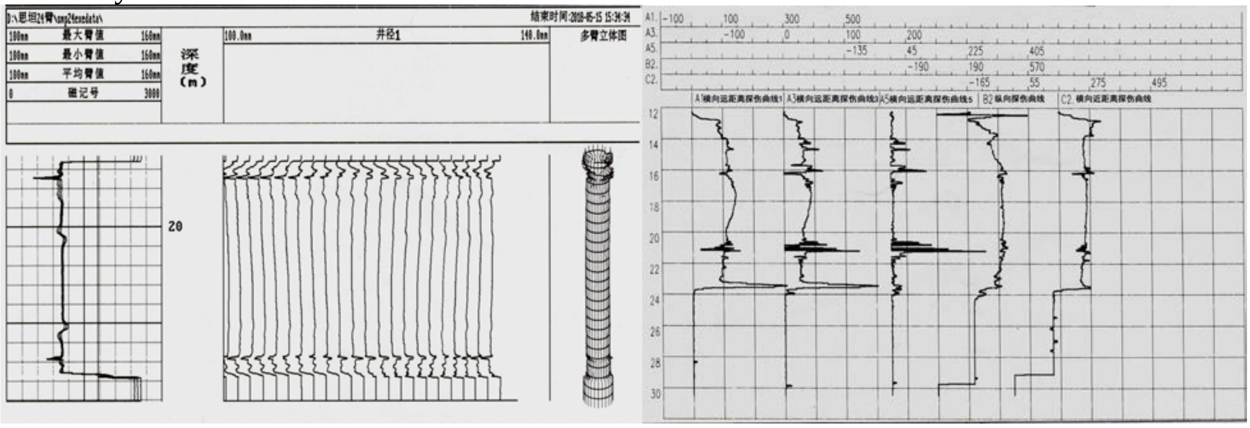


Figure 6 B Manufacturer-275 casing diameter and electromagnetic flaw detection log

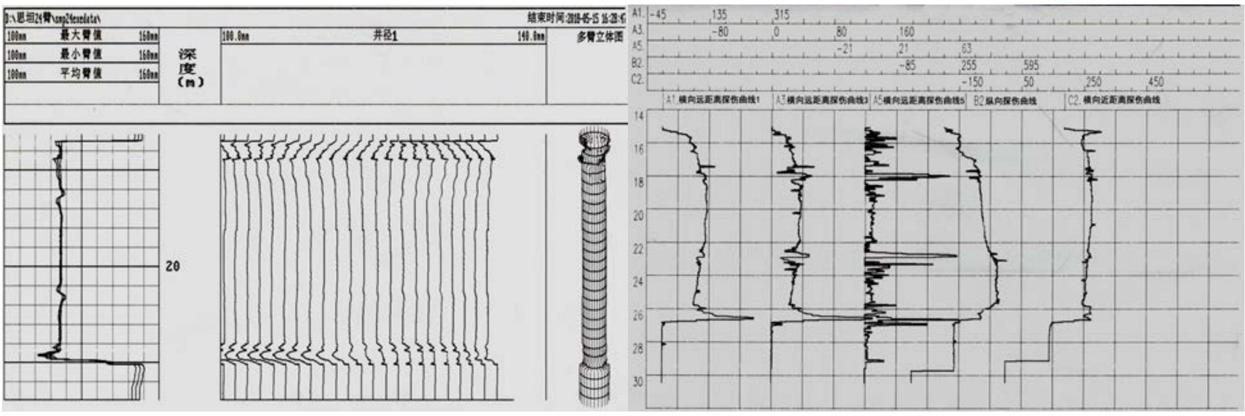
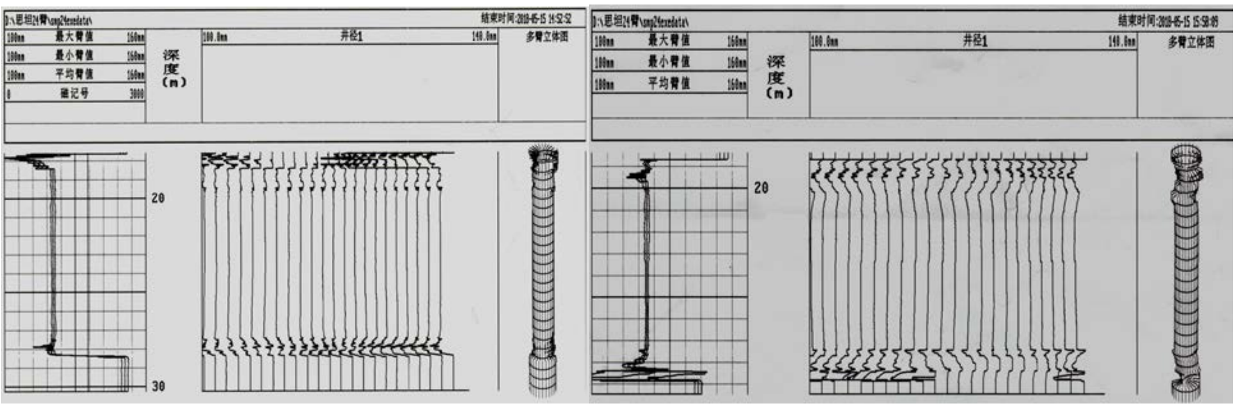


Figure 7 B Manufacturer-159 casing diameter and electromagnetic flaw detection log



B manufacturer-101 casing C manufacturer-251 casing

Figure 8 Multi-arm caliper logging curve

4. Conclusion

1) Small-diameter multi-arm caliper and electromagnetic flaw detection logging technology is applied in deep gas well combination, which accurately and detailedly describes the condition of the downhole casing, providing a solid basis for the manufacturer to choose the next fracturing, completion method and workover plan. At the same time, the quality of the casing is tested on the

ground before the completion of the well.

2) It is recommended to carry out casing quality inspection before fracturing of all deep gas wells to avoid problems due to the quality of casing pipe and affect the later fracturing construction.

3) Electromagnetic flaw detection instrument The test effect of 13Cr casing on deep gas well anti-corrosion is not good, and the curve amplitude is small. It is recommended that Party A carry out experiments on 13Cr anti-corrosion casing instrument to improve the measurement accuracy and effect of the instrument.

References

[1] Zhu Jun. Application of multi-arm caliper logging technology in oil field casing damage detection [J]. Foreign Well Logging Technology, 2008(4): 54-56.

[2] Yang Xiaoping, Zou Xiangwen. Electromagnetic flaw detection technology for multi-layer pipe column of injection and production wells in underground gas storage[J]. Foreign Well Logging Technology, 2009 (1): 43-46

[3] He Haijun. Research on casing combination and anti-corrosion completion technology of CO2 deep gas wells [D]. Chengdu University of Technology, 2012: 1-90.

[4] Ye Limei. Analysis of the effect of heat treatment process on the strength and microstructure of 17-4PH stainless steel [J]. World Nonferrous Metals, 2017 (5): 10-11.

[5] Hu Yi. Analysis of Alloying and Strengthening Mechanism of 17-4PH Steel[J].Sichuan Metallurgy, 2012, 34(2): 56-58.

[6] Wang Hui.Application of casing damage detection technology in oilfield production[J].Journal of Yangtze University(Natural science edition),2017,14(11):40-42.