

# Non-magnetic drill collar failure analysis and prevention measures

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**Abstract.** Non-magnetic drill collar is a kind of drill collar made of high quality stainless steel in drilling tool. It is widely used in oil fields, but its failure rate is rising directly, and the oil well is safe. In order to better the failure reasons explored, this article through to the non-magnetic drill collar failure parts of the macroscopic characteristics, chemical composition, mechanical properties and metallographic analysis, study the cause of non-magnetic drill collar failure and failure causes and failure process for seeking the non-magnetic drill collar failure before the defects of some form of expression and master some regularity of no magnetic drill collar failure, for we can effectively prevent the non-magnetic drill collar failure accidents mat set a foundation, but also effectively control magnetic drill collar failure accidents occur frequently.

In view of the above analysis conclusion, this paper puts forward a set of non-magnetic drill collar failure prevention measures, it effectively avoid due to its failure will continue to use with the hidden trouble of non-magnetic drill collar failure risk.

## 1. Research Ideas

(1) Through the analysis of the macroscopic properties, chemical composition, mechanical properties and tissue metallography of the non-magnetic drill collars, the reasons for the failure of magnetic drill collars are studied.

(2) Find out the form of defects before the failure of magnetic drill collar and the gradual change of the defect before failure.

(3) In view of the non-magnetic drill collar failure before all sorts of subtle changes to determine the feasible detection methods and to detect method applies it in the form of normalized before use and use in the detection of non-magnetic drill collar, effective prevention measures are put forward finally.

## 2. Analysis of Non-Magnetic Drill Collar Failure Phenomenon

When drilling pressure suddenly fell, first consider whether the cracks, because it's no magnetic steel raw material mechanical properties than ordinary steel more toughness, impact energy is very high, the rate of crack propagation unhappy even through ontology the wall thickness is not direct fracture accident, only when the multipoint stabbed or puncture the sudden fracture aperture is too large. Therefore, when the leakage occurs, the drilling fluid will be ejected from the body crack, causing the drilling pressure to drop suddenly.

Thread failure forms to leak and fatigue fracture failure as shown in figure, the reason is due to the region at the same time by the tensile, compression, torsion, bending, vibration, friction, impact and other load fatigue damage are produced by combined action of fatigue and abrasion, position mainly in three thread position near the roots.





Wear out, often occurs in two: 1. When the non-magnetic drill collar by the whole drill string as the repeated action of bending moment is passed, non-magnetic drill collar thread teeth between the relative displacement happens, happen in pressure under the action of wear and tear, cause tooth type change, reduce the intensity of threaded connections, resulting in thread wear figure. 2. In the process of drilling, non-magnetic drill collar outer surface, direct contact with all kinds of rocks and composite force will increase the surface wear is shown in figure, so there may be in a rock surface wear sharply when working outside diameter is too small or severe eccentric.

Wear, reduce overall torsional performance of non-magnetic drill collar, serious eccentric wear and easy to create convenient conditions for stress corrosion thorn leakage, lead to uncertainty of wear failure. Corrosion failure. During drilling, sulfide can cause stress corrosion crack, puncture or fracture when drilling into sulfur-bearing stratum. Similarly, the drilling fluid containing chloride and chloride ions can easily cause stress corrosion in the non-magnetic drill collar.



### 3. Physical and Chemical Test after Failure of the Drill Collar

#### 3.1. Tensile, Impact and Hardness test

Accordance with API Spec 7-2008 standard, the tensile, impact and hardness test is conducted in the vicinity of the non-magnetic drill collar fracture. Longitudinal bar tensile samples within the range from 12.5mm diameter, gage length is 65mm, the test results are shown in table 1, 1 # for the initial tensile test specimens, the tensile fracture position normal (within the range), but the tensile strength and yield strength do not meet the requirements of API Spec 7-2008 standard <sup>[4]</sup>. To conduct re-inspection then take 2 # and 3 # sample, test results show that the tensile strength of samples # 2 and # 3 and lower yield strength, test specimen fracture, found 2 # and 3 # sample fracture are within the range defects (due to the sending within a large number of crack defects, non-magnetic drill collars from tensile samples are hard to avoid these defects), the fracture morphology is shown in figure 2.

The sample size of the longitudinal charpy impact sample is 10 x 10 x 55mm. The hardness test of 30mm hardness ring was carried out, and the test results were shown in table 2. It can be seen from the table that the hardness of the drill collar does not meet the requirements of API Spec 7-2008 [4].

**Table 1.** Test results of non-magnetic drill collar stretching and impact performance

The sample number	R <sub>m</sub> [MPa]	R <sub>p0.2</sub> [MPa]	A [%]	Longitudinal impact work AKV[21] °C	
				A single value [J]	The average [J]
1#	788.4	414.9	52.2	150	147
2#	679	406	18.2	153	
3#	574	403	14	138	
API SPEC 7-2008 provisions	≥827	≥758	≥18	—	—



**Figure 1.** Tensile fracture of non-magnetic drill collar

**Table 2.** hardness test results /HB

location	hardness			API Spec 7-2008 Specify a single value requirement.
	1	2	3	
The tube body	outside	226	231	241
	In the	231	226	226
	Within the	222	224	217

3.2. Tissue Analysis Test

Microstructure observation was performed on the drill collar along the transverse cutting of the gold phase specimen, as shown in Fig. 2. It can be seen from the figure that the structure of the drill collar is austenite, and the grain boundary corrosion is more serious. The non-metallic inclusions were graded along the longitudinal cut and the grain size was 8. See table 3.



**Figure 2.** Non-magnetic drill collar metallographic structure

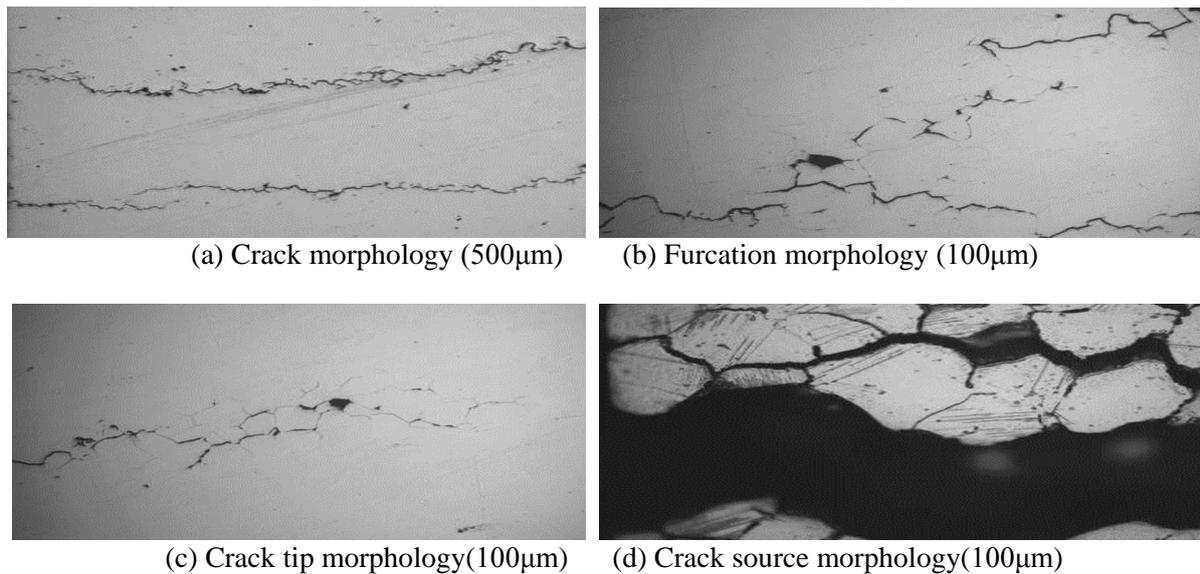
**Table 3** Non-metallic inclusion rating and grain size in steel

Nonmetallic inclusion level	A	B		C		
	Department of coarse	Department of fine	Department of coarse	Department of fine	Department of coarse	Department of fine
	0 level	0 level	0 level	1.0 level	0 level	0.5 level

#### 4. Macroscopic and Microscopic Analysis Test of the Failure of the Drill Collars

##### 4.1. Macro Analysis Test

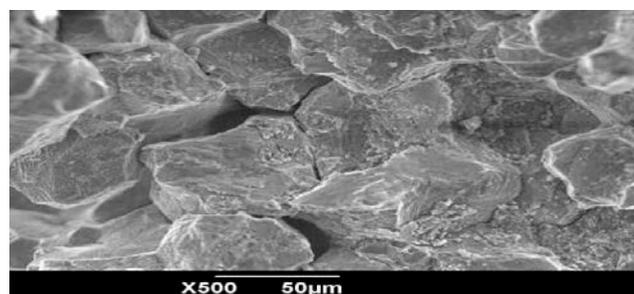
In the absence of magnetic drill collar fracture sampling, the path of crack propagation under metallographic microscope is shown in Fig. 3. As can be seen from the figure, the crack originates from the inner wall of the drill collar and is spread along the crystal expansion [1]. The results show that the steel performance of this fracture position has not reached the specified standard.



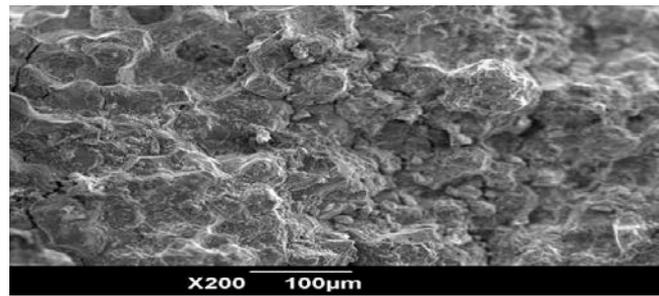
**Figure 3.** Crack propagation path of no magnetic drill collar

##### 4.2. Micro Analysis Test

The longitudinal crack of the non-magnetic drill collar was opened mechanically, and the morphology of the fracture was observed by scanning electron microscope, as shown in Fig. 4 and Fig. 5. As can be seen from the figure, the fracture characteristics of the fracture along the crystal are consistent with those observed under the metallographic microscope. As shown in figure 6 and table 4, there is a large gap between the grain grains of the crack source area and corrosion products on the fracture surface (32.79% oxygen element and 0.26% chlorine element). It is concluded that the radial crack of the unmagnetic drill collar is caused by the corrosion failure of chloride.



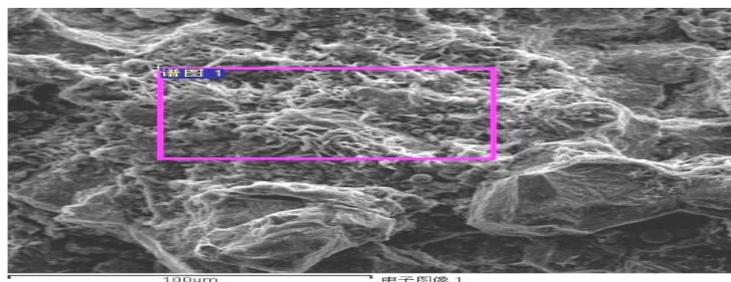
**Figure 4.** The origin of the crack (near the inner wall)



**Figure 5.** Morphology of crack expansion zone

**Table 4.** Results of energy spectrum analysis (Wt.%)

spectra	C	O	Na	Al	Si	Cl	Ca	Cr	Mn	Fe	The total
spectra 1	5.82	32.7	3.62	1.02	2.20	0.26	0.44	3.27	15.8	35.5	100.00



**Figure 6.** Energy spectrum analysis position (100µm)

### 5. Non-magnetic Drill Collar Failure Prevention Measures[2]-[3]

According to the above analysis results, there is the possibility of puncture and fatigue fracture failure in the threaded joints of the non-magnetic drill collar. At the same time, the main body has the possibility of wear failure and corrosion failure. Therefore, we made the following measures for these measures:

- (1) Select high-quality non-magnetic steel raw materials.
- (2) Optimize the design of non-magnetic drill collar thread structure.
- (3) Optimized drill string coordination design.
- (4) Optimized drilling well body design.
- (5) Strengthen the field detection of non-magnetic drill collar.
- (6) The non-magnetic drill collar is classified and managed, and the accident rate is reduced by strengthening the level management level.

### 6. Conclusion

1. Due to the use of high quality non-steel steel at the source of processing, the probability of quality problems and failure accidents of non-magnetic drill collars is relatively low.

2. We give priority to the high performance thread with the stress dispersion tank and the double shoulder structure when designing the thread, so as to reduce the stress concentration in the root of the non-magnetic drill collar.

3. With Through the optimization of the drill string, we think reasonable bending strength than you can make the non-magnetic drill collar male joint and female joint strength to achieve a balance between relations, reduce the non-magnetic drill collar the chance of fatigue crack.

4. Reduce accident rate by strengthening hierarchical management level. Provide the basis for the judgment of the cause of technical accident and the later rectification measures.

**References**

- [1] Wang zhiqing, Tian zeng, Du zhijie, Analysis of fracture causes of threaded joints in an oilfield drill collar [J]. Physical and chemical test, 2016-07-08.
- [2] Wang yin角度. Failure analysis and prevention of oil and gas pipeline through drill pipe [D]. Xi'an: xi'an university of petroleum, 2015-5-20.
- [3] Li dandan. Analysis on the failure and improvement measures of drill collar threads [J]. China petroleum and chemical standards and quality, 2013, (8): 68-69.
- [4] SY/T5144-2013. Oil drill collar [S].