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Semi-Premium Joint "JFERABBIT™" for OCTG

1. Introduction

Recently, relatively shallow wells on land have been developed for shale oil and gas extraction. In a horizontal well along a shale layer, high torque resistance performance is required in the connections because the production pipe is inserted while rotating, and seizure (galling) resistance and airtightness of the connections are also required. It is known that conventional API buttress connections do not satisfy torque resistance and airtightness requirements, and depending on the operating environment, this may lead to an accident in which a coupling cracks due to high hoop stress[1]. Premium joints with an independent seal part provide high airtightness, but on the other hand, their production cost is high due to the high dimensional accuracy required in processing. Thus, it is difficult to say that these joints are suitable connections for shale development, which can satisfy both performance and price requirements. To meet these needs, JFE Steel developed the semi-premium joint JFERABBIT™ for shale development.

2. Features of JFERABBIT™

JFERABBIT is a connection which is designed so that the pins (pipes with male screws) butt each other at the center of the coupling, as shown in **Fig. 1**. The features of the design are described below.

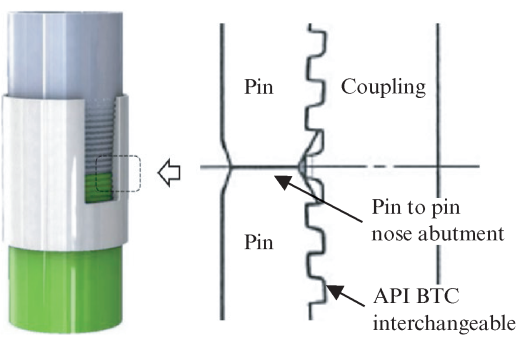

Fig. 1 Design overview of JFERABBIT™

† Originally published in *JFE GIHO* No. 54 (Aug. 2024), p. 56−58

2.1 Pin to Pin Nose Abutment

As illustrated in Fig. 1, JFERABBIT is designed so that the pin tips butt against each other at the center of the coupling. High torque resistance is obtained by butting with a wide contact area of the pin tips. In comparison with the API buttress connection, high airtightness is obtained by using this part as a seal part, and high fatigue resistance is also obtained as a structure. The evaluation of these performance features is described in Chapter 3.

2.2 Compatibility with API Buttress Connections

The thread shape of JFERABBIT is designed to be compatible with the API buttress thread. Therefore, JFERABBIT can also be used with the existing API buttress threaded accessories.

2.3 Reduction of Hoop Stress by Optimization of Thread Interference

In API buttress connections, the mechanically tightened length (length tightened by the tightening machine after pipe and coupling interference) is set uniformly to 0.500 inches (12.7 mm) from the outside diameter (OD) of 5 inches (127 mm) to 13 3/8 inches (339.725 mm), and to 0.400 inches (10.16 mm) for the OD of 4 1/2 inches (114.3 mm). Therefore, as shown in **Fig. 2**, the amount of thread interference relative to the outside diameter is large in sizes with small ODs, resulting in high hoop stress in the coupling, as can be seen in **Fig. 3**. JFERABBIT reduces this hoop stress by setting a constant ratio of the thread interference and outer diameter, thereby preventing cracking caused by hoop stress when it is used in a well.

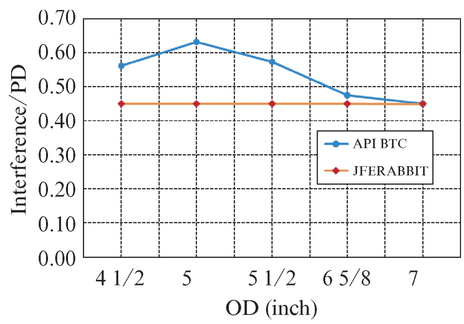

Fig. 2 Comparison of thread interference with pin OD

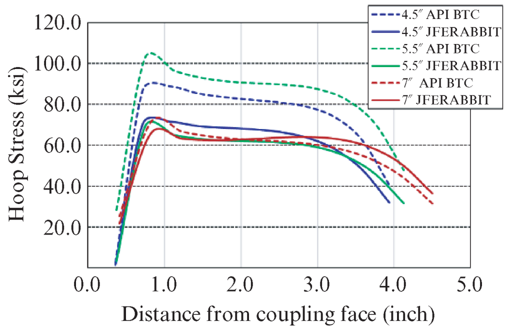

Fig. 3 Comparison of hoop stress in couplings

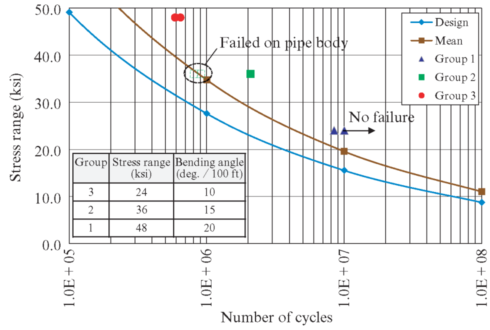

Fig. 4 Fatigue test data

Table 1 Example of max. torque during make-up and operation

OD (inch)	Weight (pound per feet)	Grade	JFERABBIT		API BTC
			Max. torque (ft-lbs)	Op. max. torque (ft-lbs)	Max. torque (ft-lbs)
5.5	20#	API 5CT P110	17 600	24 300	4 700
5.5	23#	API 5CT P110	20 800	24 500	4 900

3. Connection Performance of JFERABBIT™

3.1 Make-Up Torque Performance

Table 1 shows examples of the allowable torque when tightening JFERABBIT and API buttress connections. JFERABBIT has a higher upper torque limit in make-up/use than API buttress connections, and thus can be applied in environments where high torque is required, such as horizontal wells.

3.2 Results of Connection Test for Shale Development

Various tests assuming use in shale wells were carried out using pipes having an OD of 5.5 inches (139.7 mm), weight of 23 ppf (pounds per foot) and grade of API 5CT P110. The test results are shown below.

3.2.1 Fatigue resistance property

In this test, a sample fixed at both ends was rotated in a state of bending (3 conditions), and the number of cycles to failure or cracking was evaluated. As shown in **Fig. 4**, the test results exceeded the B1 curve defined by DNVGL RP C203: 2016, confirming that the samples had sufficient fatigue resistance.

3.2.2 Hydraulic test simulating hydraulic fracturing

As shown in **Fig. 5**, a test in which 50 cycles of the Minimum Internal Yield Pressure were applied for 30 minutes was conducted, as specified in API 5C3. As a result, no leakage or other abnormalities were observed, confirming that the sample possessed sufficient performance.

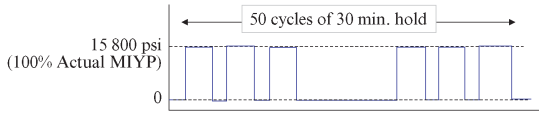

Fig. 5 Hydraulic fracturing simulation test overview

Table 2 Overview of seal test assuming shale environment

Procedure	ISO13679: 2002 CAL II TS-B modified Load points are shown in the Figure 6 and sequence is follows. CCW (LP1-LP2-...-LP6-LP7) -CW-CCW
Load condition	Max tension: 95% PBYS Max compression: 60% PBYS Max gas pressure: 10 000 psi

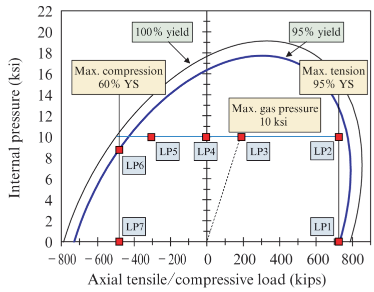

Fig. 6 Load point for seal test assuming shale environment

3.2.3 Airtight test simulating gas production (TS-B, axial force + internal pressure)

Based on ISO13679: 2002 CALII TS-B, gas sealability was evaluated under the loading conditions shown in **Table 2** and **Fig. 6**. As a result of the test, no leakage or other abnormalities were observed, confirming sufficient performance.

3.2.4 Airtight test simulating gas production (TS-C, thermal cycle)

Based on ISO13679: 2002 CALII TS-C, gas tightness was evaluated under the loading conditions shown in **Fig. 7** and **Table 3**. No leakage or other abnormalities were observed, confirming sufficient performance.

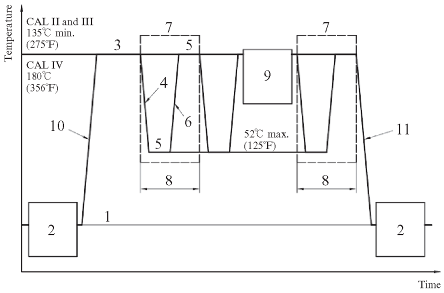

Fig. 7 Thermal cycle test procedure

4. Conclusion

JFERABBIT™ has received a high evaluation for the features introduced in this paper and the results of various tests, as well as the ease of tightening work in wells, and production volume is increasing smoothly.

References

1) Burns, M. G.; Buehler, W. M. Analysis of High-Collapse Grade P110 Coupling Failures. Materials Science & Technology (MS&T). 2010, vol. 2, p. 1440–1450.

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Table 3 Thermal cycle test condition

Step no. in Fig.7	Test	Temp (deg. F)		Tension	Pressure	Hold	Cycles
		Cold	Hot	%	psi	Min.	Time
2	Cold mechanical cycle	Amb.	-	80⇔0	10 000⇔0	5	5
3	Hot hold	-	275	80⇔0	10 000⇔0	60	1
7	Thermal cycle	125	275	80	10 000	5	5
9	Hot mechanical cycle	-	275	80⇔0	10 000⇔0	5	5
7	Thermal cycle	125	275	80	10 000	5	5
2	Cold mechanical cycle	Amb.	-	80⇔0	10 000⇔0	5	5