EXPERIMENTAL ANALYSIS OF NONDESTRUCTIVE TESTING OF DRILL PIPES

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ABSTRACT *This paper studied the following aspects: theoretical aspects of the dimensional check of tool joints, with exemplifying process flow of the drill pipe nondestructive testing and developing a graphical user interface used to fit the drill pipe in wear class according API RP 7G standard. Were analyzed special connections as NC 50 of the 5 in drill steel, grade S 135. According to this purpose were monitored tool joints of 310 drill pipe after 800 hours of operation.*

Keywords: experimental analysis, nondestructive testing, drill pipe, API standard RP7G

1. Theoretical issues

In order to continue the research on drilling problems an rigorous and careful analysis of the current state of tubular material used in drilling is required.

The drill string has to be closely monitored in terms of wear as the boring lead to serious accidents of soil, in particular the aquifer.

Threaded joints of drill string are used to assemble screw drill pipes elements, ensuring tightness, transmission torque, axial force and bending moments that appear during drilling operations and handeling. Given the frequency of the drill and handel, threaded joints must ensure a fast and safe screwing and unscrewing.

Tool joints are necessary to fulfill the drill string, but in the same time are the weak element of the ensemble, i.e. where most breaks occur.

The necessity of the drill pipes inspection is so obvious. Standards for the classification of tubular material on wear classes are used to guide inspections of drilling equipment after several hours of use. Usually checking is done at 800 hours

Inspection of drill pipes inludes:

a) for tool joint:
- examination to determine grade, seal condition, thread conditions and box swell;
- measurement of basic connection dimensions;
- wet fluorescent magnetic particle inspection using active direct current (DC) magnetic field.

b) for drill pipe body:
- examination of inside and outside surfaces for mechanical and corrosion damages;
- full length measurement to locate areas of outside diameter (OD) reductions and expansions;
- measurement of remaining wall thickness at points of apparent maximum wear;
- flux leakage detection inspection for transverse flaws;
- inspection of external slip, chain and upset areas to detect transverse flaws.

Fig. 1 shows the full inspection program for tool joint and pipe body.

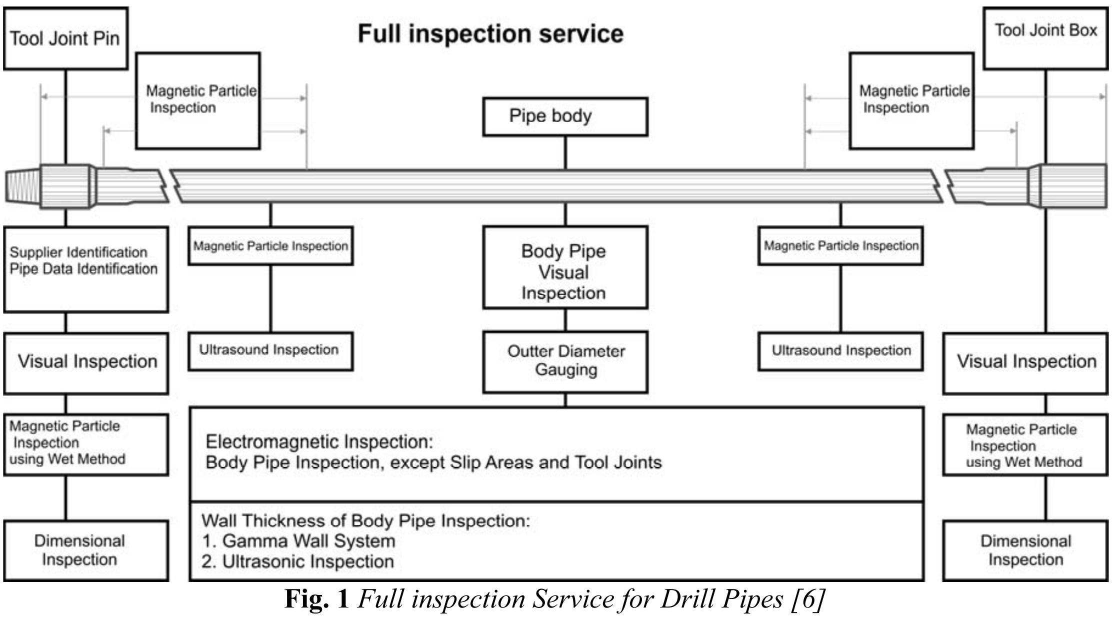

Fig. 1 *Full inspection Service for Drill Pipes [6]*

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Tool join pin and box inspection includes identification of supplier and pipe data, visual inspection, dimension control, magnetic particle inspection, evaluation of seal condition.

Body pipe inspection includes visual inspection, flux leakage detection inspection, ultrasound (UT) wall thickness measurement and outter diameter gauging.

2. Non destructive testing of drill pipe

After income in tubular base, pipes are offloaded to racks and cleaned. Cleaning includes removal of thread protectors, external and internal high pressure water cleaning, final thread cleaning before inspection, determination of pipe numbering, visual inspection for straightness.

Body pipe and tool joint pin and box inspection includes identification of supplier and pipe data, visual inspection, dimension control, magnetic particle inspection, evaluation of seal condition.

Slip Area pin and / or box inspection includes UT end area inspection and magnetic particle inspection.

In terms of dimensional measurements the following special connection sizes are checked (figure 2) [2, 5]:

- Pin inside diameter (B);
- Box outside diameter(A);
- Bevel diameter(G);
- Pin neck length (I);
- Box and pin tong space (D_M , D_C);
- Box shoulder width (C);
- Box seal width (H)
- Box counterbore depth and diameter(E, F).

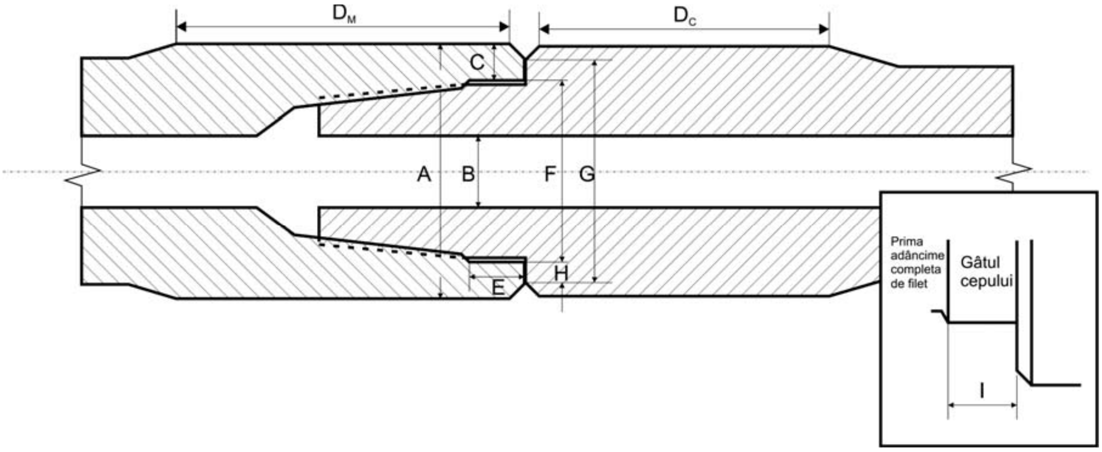

Fig. 2 *Tool joint dimensions for API connections [2, 5]*

Procedure and acceptance criteria for NC 50 API connections are [5]:

- the outside diameter of tool joint box shall be measured 3/8±1/8 inch from shoulder.At least two measuremns shall be taken spaced at intervals of 90±10 degrees;
- the pin inside diameter shall be measured under the last thread nearest the shoulder (±1/4 in);
- the box shoulder width shall be measured by placing the straightedge longitudinally along tool joint;
- box and pin tong space shall be made from the bevel to the edge of the hardfacing;
- the counterbore depth shall not be less than 9/16 inch;
- the box counterbore diameter shall be measured as near as possible to the shoulder;
- the bevel diameter on both pin and box shall not exceed the maximum acceptance values;
- box seal width shall be measured at its smallest point and shall equal or not exceed the minimum acceptance values;
- pin neck length (the distance from the 90 degree pin shoulder to the intersection of the flank of the first full depth thread with the pin neck) shall be measured and not exceed 9/16 inch;
- box shoulder flatness shall be verified by placing a straightedge across a diameter of the tool joint face and rotating the straighedge at least 180 degrees along the plane of the shoulder. Any visible gaps shall be cause for rejection. The procedure shall be repeated on the pin with the straightedge placed across a chord of the shoulder surface.

Acceptable connections shall be coated with an API tool joint compund over all thread and shoulder surfaces including the end of the pin.

Finishing part of inspection includes:

- pipe classification,
- marking,
- application of lubricant,
- installation of protectors,
- sorting to good or rejected pipe and
- final reporting.

The outgoing of pipe includes an intermediate outgoing control.

3. Comparative study of modeling and simulation of NC 50 tool joints for more efficient classification in wear classes

The analysis of an experimental batch of 310 drill pipe 5in S135 has been recorded dimensional parameters of the tool joints NC50 after 800 hours of operation.

Following measurements obtained on the analyzed group drill designed a graphical interface in Matlab and were made computer programs to restore the values varying sizes indicated checked for wear Premium class in the standard API. Graphical interface build is represented in Figure 3

Experimental data obtained were compared to the API Acceptance Criteria. According to API for 5 inch, S135 grade drill pipes, the NC50 tool joint nominal sizes are included in table 1 [1].

Table 1

Dimension	Nominal value [mm]	Tolerance [mm]
Box outside diameter (A)	168,275	±0,794
Pin inside diameter (B)	69,850	+0,397 - 0,794
Pin tong space (D_C)	177,8	±6,350
Box tong space (D_M)	254	±6,350
Box counterbore diameter (F)	139,9375	±0,794
Bevel diameter (G)	153,988	±0,397

Acceptance Criteria for Premium an Class 2 Drill Pipes according API are included in table 2 [1].

Table 2

Dimension	Premium [mm]	Class 2 [mm]
Box outside diameter	Min 160,3375	Min 157,1625
Pin inside diameter	Max 86,518	Max 92,075
Box seal width:	Min 11,509	Min 9,92

From measurements made on analyzed drill pipes have designed a graphical interface (GUI) in Matlab and computer programs to play varying sizes checked against API acceptance criteria.

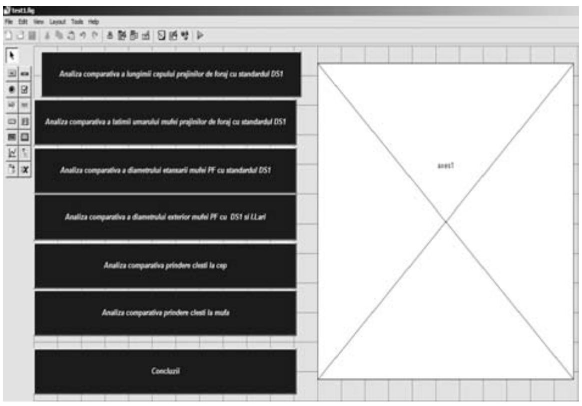

Fig. 3 *Graphic interface for experimental analysis*

From this interface one can observe comparative analyzes for each dimension and presented in the following:

- Comparative analysis of shoulder width variation with the standard API acceptance criteria (fig. 4)
- Comparative analysis of box outside diameter variation with the standard API acceptance criteria (fig. 5)
- Comparative analysis of pin neck length variation with the standard API acceptance criteria (fig. 6)

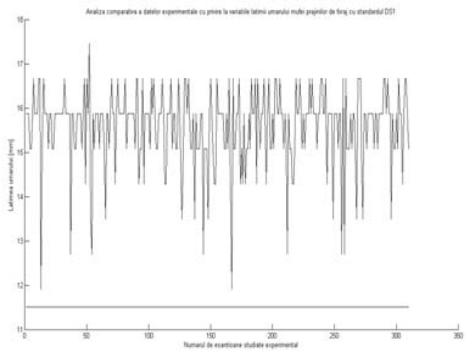

Fig. 4 *Comparative analysis of shoulder width variation with the standard API acceptance criteria*

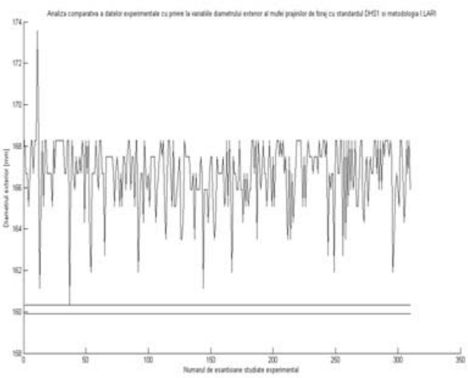

Fig.5 *Comparative analysis of box outside diameter variation with the standard API acceptance criteria*

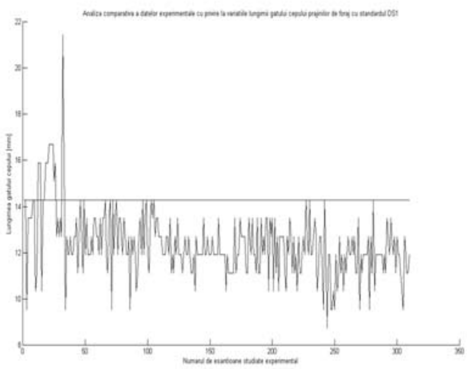

Fig. 6 *Comparative analysis of pin neck length variation with the standard API acceptance criteria*

4. Conclusions

a. By comparing the measured values for the shoulder width on sample rod with the standard API acceptance criteria (29/64 inch = 11.05 mm) it can be seen that no pipe has no value under the API acceptance criteria;
b. By comparing the measured values for the box outside diameter on sample rod with the standard API acceptance criteria (6 5/16 inch = 160,3375 mm) it can be seen that 6% from total number of pipes has this value under the API acceptance criteria recommending their downgrading and their classification in class wear one;
c. By comparing the measured values for the neck length on sample rod with the standard API acceptance criteria it can be seen that there are pipes with neck length bigger than acceptance criteria. In this situation the first loop of thread will not provide gathering up the last loop of box thread and the sealing will be compromised. To avoid this problem re-threading the pin is recommended;
d. The graphical interface is provided with the opportunity to centralize comparisons made in order to return to a situation of balance sheets as follows:
- Drill pipes in the analyzed group can be assigned only 8.1% in class Premium wear;
- Efficient use of the drill, based on standardized criteria for classification in wear classes is recommended that the poles inspected 91.9% 800 hours of operation to be downgraded and wear in class 1;
e. Because of many facilities of any GUI, and in this case too, the model created can be used for any type of connection with known specifications for class wear.

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