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Natural gas — Upstream area — Determination of drag reduction in laboratory for slick water

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Foreword

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This document was prepared by Technical Committee ISO/TC 193, *Natural gas*, SC 3, *Upstream area*.

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Introduction

Shale gas needs large-scale volume fracturing to achieve commercial exploitation, slick water is an important part of volume fracturing technology, and its drag reduction directly affects shale gas fracturing operation. If the drag reduction of slick water is too low, it causes the high fracturing operation pump pressure, greatly increase the cost, and even cause the failure of the fracturing operation. This document aims at evaluating the drag reduction performance of slick water.

Natural gas — Upstream area — Determination of drag reduction in laboratory for slick water

1 Scope

This document specifies a method for the determination of drag reduction of slick water, which is mainly used to evaluate the drag reduction performance of slick water.

This document uses the pipeline method to evaluate the drag reduction, which is currently recognized as the best method to evaluate the drag reduction performance.

This document describes the device, experimental conditions and operating steps in detail. The drag reduction value obtained by evaluation according to this document can effectively represent the on-site drag reduction performance.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
differential pressure
pressure difference between two points in the system

3.2
drag reduction
pipe flow friction of a given fluid relative to the pipe flow friction of distilled or de-ionized water

3.3
slick water
water-based fracturing fluid, composed of drag-reducing agent, other additives and water

3.4
volume fracturing technology
process of injecting water and sand at a high enough pressure into a well to break the rock and expanse natural fractures, in order to free up oil or gas reserves

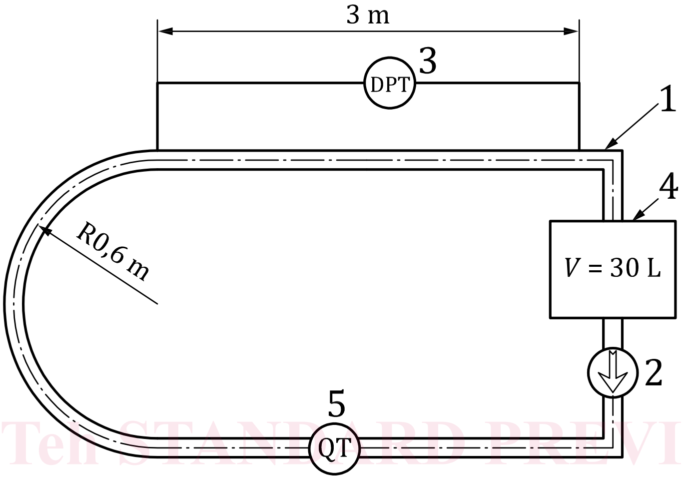
3.5
fresh water
distilled water or de-ionized water with a pH of 6 to 9

4 Principle

4.1 Working principle of drag reduction test by fluid flow loop

The sketch of the measuring principle is shown in Figure 1. During the test, as the fluid is circulated in the flow loop by the pump, the drag reduction of the liquid in the corresponding length of the pipe is measured by the differential pressure sensor.

The illustrated equipment is for reference only. The actual experimental equipment can be all the equipment that meets the requirements of Clause 5.



Key

1 test pipe
2 pump
3 differential pressure sensor
4 mixing tank
5 flow meter

Figure 1 — Working principle of the fluid flow loop

4.2 Calculation formula

The drag reduction of slick water is calculated by Formula (1):

$$D_R = \frac{\Delta p_1 - \Delta p_2}{\Delta p_1} \times 100 \quad (1)$$

where

D_R is the drag reduction of slick water, %;

Δp_1 is the pressure difference when fresh water flows through the pipe, keep the same sample, Pa;

Δp_2 is the pressure difference when slick water flows through the pipe, keep the same sample, Pa.

NOTE The reference conditions are 25 °C, 101,325 kPa.

5 Measurement device

5.1 Fluid flow loop

5.1.1 Mixing tank

A mixing tank of no less than 30 l is used to fill the test liquid. The mixing tank should be equipped with mechanical stirring system composed of motor, stirring rod and stirring blade, the stirring speed is (500 ± 100) r/min.

5.1.2 Test pipe

The test pipe is an open circuit composed of a curved pipe and straight pipes. The average roughness of the inner steel pipe surface shall be 3,2 µm ± 1 µm (average roughness *Ra*, see ISO 8503-4), the diameter of the curved pipe is 0,6 m, the length of the straight pipe ≥ 6 m. The pipe inner diameter is 8 mm.

5.1.3 Pump

A progressive cavity pump is used to circulate the test liquid. The range of flow rate is minimum (0 to 2) $m^3 \cdot h^{-1}$.

5.1.4 Flow meter

A mass flow meter is used to test the flow rate of the test liquid. The range of measurement is minimum (0 to 35) kg min^{-1} and the relative error of the flow meter is maximum 0,20 %.

5.1.5 Pressure sensor

A differential pressure sensor or two absolute pressure sensors are used to test the differential pressure of the test liquid. The range of measure is 0 kPa to 700 kPa, and the relative error of the pressure sensor is ±0,25 % full scale.

5.2 Electronic balance

Maximum weighing is minimum 100 g, weighing accuracy at least 0,01 g. It is used to weigh the solid drag-reducing agent.

6 Reagents and materials

6.1 Water

Distilled or deionized water is used to prepare the slick water.

6.2 Additive

Prepare additives for slick water, such as drag-reducing agent, surfactant, bactericide, etc., the purity of additives is required according to the test requirements.

7 Measurement

7.1 Preparation

Prepare the slick water according to the prescribed composition including water, drag-reducing agent, surfactant, bactericide, etc.

7.2 Measurement of drag reduction

7.2.1 Prepare 20 l of fresh water in the mixing tank. Circulate the water at 10 m/s in the test loop. Meanwhile, record the differential pressure (Δp_1) and flow rate every reading second until the change amplitude of Δp_1 value of last ten readings is less than ±1 %.

7.2.2 Drain the water from the tank and recirculate the new fresh water at the same flow rate as 7.2.1, and inject drag-reducing agent and additives into the mixing tank. Continuously adjust the pump power to keep the flow rate constant. Meanwhile, record the differential pressure (Δp_2) and flow rate per second until the change amplitude of Δp_2 is less than ±1 %.

7.2.3 Drain the water from the tank and recirculate the new fresh water at the same flow rate as 7.2.1. Repeat the cleaning steps twice and every step lasts five minutes, if the difference from actual reading to (Δp_1) value is less than ±1 %, the device is cleaned.

7.3 Data processing

The slick water drag reduction shall be calculated according to Formula (1). The result should have at least one significance digit of decimal.

7.4 Protocol

Under the test conditions required by this document, the data of the pressure difference per meter is shown in Table 1.

Table 1 — Data of the pressure difference per meter

Inner diameter mm	Water circulate rate m/s	Typical fresh water pressure difference per meter kPa/m	Typical Slick water difference per meter kPa/m
8	10	90 to 120	15 to35

8 Repeatability

In the analytic range given by this document, under repeatability conditions, the absolute deviation of the test results of the two parallel samples should not exceed 5 %.