INTERNATIONAL STANDARD

ISO 10426-6

First edition
2008-07-01

Petroleum and natural gas industries — Cements and materials for well cementing —

Part 6:
Methods for determining the static gel strength of cement formulations

Industries du pétrole et du gaz naturel — Ciments et matériaux pour la cimentation des puits —

Partie 6: Méthodes de détermination de la force statique du gel des formulations de ciment

Reference number
ISO 10426-6:2008(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10426-6 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 3, *Drilling and completion fluids, and well cements*.

ISO 10426 consists of the following parts, under the general title *Petroleum and natural gas industries — Cements and materials for well cementing*:

— *Part 1: Specification*

— *Part 2: Testing of well cements*

— *Part 3: Testing of deepwater well cement formulations*

— *Part 4: Preparation and testing of foamed cement slurries at atmospheric pressure*

— *Part 5: Determination of shrinkage and expansion of well cement formulations at atmospheric pressure*

— *Part 6: Methods for determining the static gel strength of cement formulations*

Introduction

Characterizing the static gel-strength (SGS) development of a cement slurry is an important design parameter in specific cementing environments. These include shallow-water flow mitigation, plugging operations and certain annular flow circumstances. Determining the gel-strength characteristics of a cement slurry allows the user to ascertain if the cement design is fit for a particular intended purpose. Historically, the SGS of a cement slurry was determined by a method using a couette-type rotational viscometer. More recently, specialized instruments, including a rotating-type apparatus, an intermittent rotation-type apparatus and an ultrasonic-type apparatus, have been used to measure the gel-strength development of a static cement slurry. This part of ISO 10426 provides the testing protocol for determining SGS using these three types of instruments.

It is necessary to note due that, due to differences in sample size, apparatus configuration and method of SGS determination, there can be considerable variance in results obtained by the three types of instruments described in this part of ISO 10426.

CAUTION — Caution is necessary when using static gel-strength development testing results as the single or predominant engineering parameter of a cement slurry design or technical evaluation.

In this part of ISO 10426, where practical, U.S. Customary (USC) units are included in brackets for information. The units do not necessarily represent a direct conversion of SI to USC, or USC to SI, units. Consideration has been given to the precision of the instrument making the measurement. For example, thermometers are typically marked in one degree increments, thus temperature values have been rounded to the nearest degree.

In this part of ISO 10426, calibrating an instrument refers to ensuring the accuracy of the measurement. Accuracy is the degree of conformity of a quantity to its actual or true value. Accuracy is related to precision, or reproducibility of a measurement. Precision is the degree to which further measurements or calculations show the same or similar results. Precision is characterized in terms of the standard deviation of the measurement. The results of calculations or a measurement can be accurate but not precise, precise but not accurate, neither or both. A result is valid if it is both accurate and precise.

Annex A of this part of ISO 10426 is for information only.

Petroleum and natural gas industries — Cements and materials for well cementing —

Part 6:
Methods for determining the static gel strength of cement formulations

1 Scope

This part of ISO 10426 specifies requirements and provides test methods for the determination of static gel strength (SGS) of cement slurries and related materials under simulated well conditions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced standard (including any amendments) applies.

ISO 10426-2:2003, *Petroleum and natural gas industries — Cements and materials for well cementing — Part 2: Testing of well cements*

3 Terms and definitions

For the purposes of this part of ISO 10426, the following terms and definitions apply.

3.1
bottom-hole pressure
BHP
hydrostatic pressure at the bottom of the well calculated from the true vertical depth and the fluid densities in the wellbore

3.2
bottom-hole circulating temperature
BHCT
maximum temperature encountered in a wellbore during cement slurry placement

3.3
critical static gel-strength period
CSGSP
time interval required for the cement to progress from the critical static gel strength value to a static gel strength of 250 Pa (500 lbf/100 ft^2)

3.4
critical static gel strength
CSGS
specific static gel strength of a cement in which hydrostatic-pressure equilibrium is reached between the decayed hydrostatic pressure transmission of the cement column (and other fluids in the annulus) and the pore pressure of the formation

See Annex A.

NOTE The critical static gel strength is measured in pascals or newtons per square metre (pounds force per 100 square feet).

3.5
static gel strength
SGS
shear strength (stress) measurement derived from the pressure required to move a gelled fluid through a pipe or annulus of known length and geometry

NOTE The static gel strength is measured in pascals or newtons per square metre (pounds force per 100 square feet).

4 Sampling

4.1 General

Samples of the dry cement or cement blend, solid and liquid additives and mixing water are required to test a slurry in accordance with this part of ISO 10426. Accordingly, the best available sampling technology should be employed to ensure the laboratory test conditions and materials match as closely as possible those found at the well site.

4.2 Method

Applicable sampling techniques for the dry cement or cement blend, solid and liquid additives and mixing water used in typical cementing operations can be found in ISO 10426-2:2003, Clause 4. If required, the temperature of the mix water, cement or cement blends, and liquid additives may be measured with a thermocouple or thermometer capable of measuring temperature with an accuracy of ± 2 °C (± 3 °F). These temperatures should be recorded. Temperature-measuring devices shall be calibrated (in the case of a thermocouple) no less frequently than every three months or checked (in the case of a thermometer) annually.

NOTE Descriptions of commonly used sampling devices can be found in ISO 10426-2:2003, Figure 1.

5 Preparation

Prepare the test samples in accordance with ISO 10426-2:2003, Clause 5. The laboratory temperature of the cement sample and mix water should be within ± 2 °C (± 3 °F) of the respective temperature anticipated at the well site. If field conditions are unknown, the temperature of the mix water and dry cement shall be 23 °C ± 2 °C (73 °F ± 3 °F) immediately prior to mixing.

If larger slurry volumes are needed, an alternative method for slurry preparation is found in ISO 10426-2:2003, Clause A.1.

NOTE The density of the cement slurry can be verified by methods found in ISO 10426-2:2003, Clause 6.

6 Test method using rotating-type static gel strength apparatus

6.1 Apparatus

The apparatus contains a pressure chamber that can be heated and pressurized according to a simulated cement job schedule. The SGS is calculated from the torque required to rotate a paddle of known geometry at very low speed. The rotation speed of the paddle during the SGS stirring portion of the test is normally a continuous 0,000 009 2 r/s (0,2°/min). The initial stirring to simulate placement in the well is typically conducted at 2,5 r/s ± 0,25 r/s (150 r/min ± 15 r/min). The rotating-type static gel strength apparatus shall be calibrated according to the manufacturer's instructions. During the test period, the temperature and pressure of the slurry in the test cell is increased in accordance with the appropriate well-simulation test schedule (see 6.2.2). Determine the temperature of the cement slurry by use of an ASTM E220 classification "special" type J thermocouple located in the centre of the testing cell. The temperature-measuring system shall be calibrated to an accuracy of ± 2 °C (± 3 °F). Calibration shall be performed no less frequently than every three months.

NOTE Changing the rotational speed of the apparatus can be required depending on slurry design. The permissible range of rotational speed for the apparatus is 0,000 006 9 r/s (0,15°/min) to 0,000 023 1 r/s (0,5°/min).

6.2 Test procedure

6.2.1 If there is a batch mixing time being used for the job, the test schedule should include this segment. The slurry should be exposed to the anticipated temperature conditions during the batch mixing time. The pressure at this time shall be atmospheric. The stirring is typically maintained at 2,5 r/s ± 0,25 r/s (150 r/min ± 5 r/min). If there is no batch mixing time, omit this step.

6.2.2 Calculate the expected time to bottom and the expected placement time required to displace the cement to the zone of interest. Ramp the cement slurry to bottom-hole circulating temperature (BHCT) and bottom-hole pressure (BHP) in the expected time to bottom. The slurry is then ramped to the circulating temperature and pressure at the zone of interest. During the placement simulation, the temperature and pressure shall be maintained within ± 3 °C (± 6 °F) and ± 2 MPa (± 300 psi) of the appropriate elapsed time versus temperature and pressure target. Within 10 min of the end of the ramp, the temperature and pressure shall be within ± 1 °C (± 2 °F) and ± 0,7 MPa (± 100 psi) of the specified values. After the circulating temperature at the zone of interest is reached, hold at the specified temperature and pressure for 5 min ± 30 s to allow for temperature stabilization to occur. The stirring is typically maintained at 2,5 r/s ± 0,25 r/s (150 r/min ± 15 r/min). The time interval to ramp to the circulating temperature and pressure at the zone of interest is the expected placement time, minus the expected time to bottom. In cases when an extended period of slurry fluidity is expected, the test temperature may be increased to BHCT in 240 min after reaching the circulating temperature at the zone of interest.

NOTE During the time of stirring at ISO rotational speeds, the test gives an indication of the slurry consistency. It is not an exact slurry consistency since the paddle does not conform to the ISO dimensions for a paddle used to determine the thickening time of a slurry.

6.2.3 For the SGS determination, at the end of the slurry placement simulation, the rotational speed is changed from the typical 2,5 r/s ± 0,25 r/s (150 r/min ± 15 r/min) to 0,000 009 2 r/s (0,2°/min) or other permissible rotational speed. Maintain circulating temperature and pressure at the zone of interest. During SGS determination the temperature and pressure shall be maintained within ± 1 °C (± 2 °F) and ± 0,7 MPa (± 100 psi) of the target values.

6.2.4 Record the initial SGS and the elapsed time when the sample is placed in SGS determination mode from the previous placement simulation. Record the time to 50 Pa (100 lbf/100 ft^2), 100 Pa (200 lbf/100 ft^2), 150 Pa (300 lbf/100 ft^2), 200 Pa (400 lbf/100 ft^2) and 250 Pa (500 lbf/100 ft^2) SGS. Where applicable, determine the critical static gel strength period (CSGSP) by measuring the time required for the cement to progress from the critical static gel strength (CSGS) value (see Annex A) to a SGS of 250 Pa (500 lbf/100 ft^2). The manufacturer, model and rotational speed of the apparatus used to make the SGS determination shall be reported.