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Petroleum and natural gas industries – Cements and materials for well cementing –
Part 5: Determination of shrinkage and expansion of well cement formulations at atmospheric pressure (ISO 10426-5:2004)

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Petroleum and natural gas industries - Cements and materials for well cementing - Part 5: Determination of shrinkage and expansion of well cement formulations at atmospheric pressure (ISO 10426-5:2004)

Industries du pétrole et du gaz naturel - Ciments et matériaux pour la cimentation des puits - Partie 5: Détermination du retrait et de l'expansion à la pression atmosphérique des formulations de ciments pour puits (ISO 10426-5:2004)

Erdöl- und Erdgasindustrie - Zemente und Materialien für die Zementation von Tiefbohrungen - Teil 5: Bestimmung der Schrumpfung und Quellung von Bohrloch-Zementmischungen bei atmosphärischem Druck (ISO 10426-5:2004)

This European Standard was approved by CEN on 30 September 2005.

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Foreword

The text of ISO 10426-5:2004 has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 10426-5:2005 by Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2006, and conflicting national standards shall be withdrawn at the latest by April 2006.

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Endorsement notice

The text of ISO 10426-5:2004 has been approved by CEN as EN ISO 10426-5:2005 without any modifications.

Introduction

Dimensional changes in oil- and gas-well cements after placement, phenomena often referred to as shrinkage, (when the dimensional change corresponds to a decrease in cement volume) have often been used to explain various wellbore phenomena including

— a microannulus, leading to a bad bond as demonstrated by the bond log;

— interzonal communication, resulting in costly remedial operations;

— lack of a hydraulic seal when utilizing cement inflatable packers.

Attempts have been made to find additives that decrease cement shrinkage (shrinkage being a fundamental characteristic of Portland cement) The best solution for shrinkage thus far has been the identification of additives that favour the expansion of the cement. However, even if cement expands dimensionally, it will still shrink internally. In this case, the bulk expansion of the cement sample is simply superimposed on an inner shrinkage that will affect the porosity of the sample.

Shrinkage and expansion in cement result from the formation of hydration products having a density different from the compounded density of the reaction components. This can result in the following:

— change in pore volume;

— change in pore pressure;

— change in sample dimensions;

— change in internal stress.

In a closed cell with a non-deformable boundary, the volume of hydrates produced during the chemical reaction is less than the volume of dry compounds plus water. The change in volume of hydrates will be referred to as inner hydration shrinkage. The change in the sample dimensions will be referred to as bulk shrinkage or expansion. Bulk shrinkage and expansion of cement refer to the result of the measurement of linear dimensional change or volume change. The volume to which all volume changes are related is the volume of the slurry immediately after mixing and emplacement in the experimental equipment.

In this part of ISO 10426, units are given as SI, and where practical, U.S. Customary units are included in brackets for information.

Users of this part of ISO 10426 should be aware that further or differing requirements might be needed for individual applications. This part of ISO 10426 is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

This part of ISO 10426 is based on API Technical Report 10TR 2 [1].

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

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

1 Scope

This part of ISO 10426 provides the methods for the testing of well cement formulations to determine the dimension changes during the curing process (cement hydration) at atmospheric pressure only. This is a base document, because under real well cementing conditions shrinkage and expansion take place under pressure and different boundary 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 document (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 document, the following terms and definitions apply.

3.1
bulk expansion
increase in the external volume or dimensions of a cement sample

3.2
bulk shrinkage
decrease in the external volume or dimensions of a cement sample

3.3
hydration shrinkage
difference in the volume between the hydration products and the volume of the dry cement, additives and water

4 Sampling

4.1 General

Samples of the neat cement or cement blend, solid and liquid additives, and mixing water are required to test a slurry according to 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 wellsite. Some commonly used sampling devices are shown in ISO 10426-2:2003, Figure 1.

4.2 Method

Applicable sampling techniques for the fluids and materials used are specified in ISO 10426-2:2003, Clause 4.

5 Determination of shrinkage or expansion under conditions of free access of water at atmospheric pressure — Annular ring test

5.1 General information

The annular expansion mould is a device suitable for measuring only the linear bulk shrinkage or expansion properties of a cement formulation. The magnitude of expansion depends on the amount of expanding agent, cement powder, slurry design and curing condition (pressure, temperature, time, fluid access). It should be noted that expansion is strongly affected by boundary conditions. The chemical process of mineral growth is strongly controlled by the state of stress and mineral growth will tend to occur where the stress value is the lowest, i.e. in pore space or empty spaces. Therefore, the degree of cement shrinkage and expansion is dependent on a number of conditions, not all of which can be uniquely defined. The test does not represent fully the annulus of a well.

5.2 Apparatus

5.2.1 Mould

5.2.1.1 General

Use corrosion-resistant material (e.g. stainless steel). The outer diameter (OD) of the inner ring shall be 50,8 mm (2 in) and the inner diameter (ID) of the outer expansion ring shall be 88,9 mm (3,5 in). See Figures 1, 2 and 3.

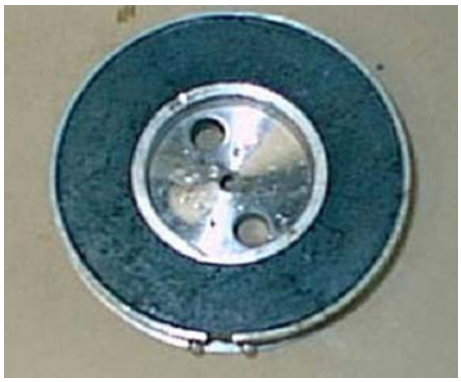

Figure 1 — Typical mould assembly (top view)

Figure 2 — Typical mould assembly (side view)