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

Part 2: Testing of well cements

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

Partie 2: Essais de ciment pour puits

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Foreword

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ISO 10426-2 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*

The following part is under preparation:

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

Introduction

This part of ISO 10426 is based on API RP 10B, 22nd edition, December 1997, addendum 1, October 1999.

Users of this part of ISO 10426 should be aware that further or differing requirements may 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 may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this part of ISO 10426 and provide details.

In this part of ISO 10426, where practical, US Customary units are included in brackets for information.

Well cement classes and grades are defined in ISO 10426-1.

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

Part 2: Testing of well cements

1 Scope

This part of ISO 10426 specifies requirements and gives recommendations for the testing 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 document (including any amendments) applies.

ISO 10414-1, *Petroleum and natural gas industries — Field testing of drilling fluids — Part 1: Water-based fluids*

API RP 13J, *Testing of heavy brines (second edition), March 1996*

ASTM C 109, *Standard test method for compressive strength of hydraulic cement mortars (using 2 in. or [50 mm] cube specimens)*

ASTM C 188, *Standard test method for density of hydraulic cement*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
absolute volume
reciprocal of absolute density

NOTE It is expressed as volume per unit mass.

3.1.2
additive
material added to a cement slurry to modify or enhance some desired property

NOTE Common properties that are modified include: setting time (by use of retarders or accelerators), fluid loss control, viscosity, etc.

3.1.3
annulus
space surrounding the pipe in the wellbore

NOTE The outer wall of the annular space may be either surface or casing

3.1.4
assumed surface temperature
T_{AS}
assumed temperature at surface used for calculating a pseudo-temperature gradient

3.1.5
batch mixing
process of mixing and holding a volume of cement slurry prior to placement in the wellbore

3.1.6
Bearden units of consistency
units used to express consistency of a cement slurry when determined on a pressurized consistometer

NOTE The symbol for consistency when expressed in Bearden units is B_C.

3.1.7
blowout
point in time at which nitrogen flows through the sample in a fluid loss test

3.1.8
bulk density
mass per unit volume of a dry material containing entrained air

3.1.9
casing cementing
complete or partial annular cementing of a full casing string

3.1.10
cement
Portland cement
ground clinker generally consisting of hydraulic calcium silicates and aluminates and usually containing one or more of the forms of calcium sulfate as an interground addition

NOTE 1 Hydraulic calcium silicates and aluminates are those which harden under water.

NOTE 2 Interground additions are added before grinding, rather than after grinding.

3.1.11
cement class
cement type
designation achieved using the ISO system of classifications of well cement in accordance with its intended use

NOTE See ISO 10426-1 for further information.

3.1.12
cement grade
designation achieved using the ISO system for denoting the sulfate resistance of a particular cement

NOTE See ISO 10426-1 for further information.

3.1.13
cement blend
mixture of dry cement and other dry materials

3.1.14
clinker
fused materials from the kiln in cement manufacturing that are interground with calcium sulfate to make cement

3.1.15
compatibility
capacity to form a fluid mixture that does not undergo undesirable chemical and/or physical reactions

3.1.16
compressive strength
strength of a set cement sample measured by the force required to crush it

NOTE It is expressed as force per unit area.

3.1.17
consistometer
device used to measure the thickening time of a cement slurry under specified temperature and pressure

3.1.18
continuous-pumping squeeze-cementing operation
squeeze-cementing operation that does not involve cessation of pumping

3.1.19
equivalent sack
mass of the blend of Portland cement and fly ash or pozzolan that has the same absolute volume as 42,63 kg (94 lbs) of Portland cement

3.1.20
filtrate
liquid that is forced out of a cement slurry during a fluid loss test

3.1.21
fly ash
powdered residue from the combustion of coal having pozzolanic properties

NOTE See Clause 17 for further description.

3.1.22
free fluid
coloured or colourless liquid which has separated from a cement slurry

3.1.23
freeze-thaw cycle
test involving a cement sample that is alternately exposed to temperatures above and below the freezing point of water

3.1.24
hesitation-pumping squeeze-cementing operation
squeeze-cementing operation that incorporates discontinuous pumping of the cement slurry

NOTE The slurry is placed into the well, the pumps are stopped for some period of time, then a volume of slurry is again pumped. The process is repeated until a predetermined pressure is reached or the volume of cement slurry has been completely pumped.

3.1.25
heat-up rate
R_h
rate of slurry temperature change on going from the surface temperature, T_{SS}, to the predicted bottom-hole circulating temperature, T_{PBHC}

3.1.26
liner cementing
annular cementing operations for which the top of the casing being cemented is not at the top the wellbore

3.1.27
mud
fluid that is circulated through the wellbore during drilling or workover operations

3.1.28
mud balance
beam-type balance used to measure fluid density at atmospheric pressure

3.1.29
neat cement slurry
cement slurry consisting of only cement and water

3.1.30
pressure-down rate
R_{pd}
rate at which pressure is reduced from the bottom-hole pressure, p_{BH}, to the pressure at the top of cement column, p_{TOC}, during a thickening-time test

3.1.31
permeability
measure of the capacity of a porous medium to allow flow of fluids or gases

NOTE Permeability is usually expressed in millidarcy, mD.

3.1.32
plug cementing
process of placing a volume of cement in a well to form a plug across the wellbore

3.1.33
pozzolan
siliceous or siliceous and aluminous material which in finely divided form reacts with calcium hydroxide to form a cementitious material

NOTE See Clause 17 for further description.

3.1.34
preflush, noun
fluid containing no insoluble weighting agents used to separate drilling fluids and cementing slurries

3.1.35
pressure vessel
vessel in a consistometer into which the slurry container is placed for the thickening-time test

3.1.36
pressurized curing vessel
vessel used for curing a sample of cement under temperature and pressure for compressive strength testing

3.1.37
pressure-up rate
R_{pu}
rate at which pressure is increased from the starting pressure to the bottom-hole pressure during a thickening-time test

3.1.38
relative density
specific gravity
ratio of the mass of a substance to the mass of an equal volume of a standard substance at a reference temperature

NOTE The standard substance is usually water; the reference temperature is usually 4 °C.

3.1.39
sedimentation
separation and settling of solids in a cement slurry

3.1.40
slurry container
container in a pressurized consistometer used to hold the slurry for conditioning purposes or for thickening-time test

3.1.41
sonic strength
extent of strength development of a cement sample calculated by measuring the velocity of sound through it

NOTE The calculation is based on specific mathematical correlations and not on direct measurements of strength.

3.1.42
starting pressure
p_S
initial pressure applied to the test sample at the beginning of the thickening-time test

NOTE p_S is also used to determine the pressure-up rate.

3.1.43
spacer
fluid containing insoluble weighting materials that is used to separate drilling fluids and cementing slurries

3.1.44
squeeze-cementing
remedial process in which cementing material is forced under pressure into a specific portion of the well such as a fracture or opening

3.1.45
static fluid loss test
test to determine fluid lost from a cement slurry when placed against a 325 mesh screen at 6 900 kPa (1 000 psi) differential pressure

3.1.46
static stability test
test to determine the degree of sedimentation and free fluid development in a cement slurry

3.1.47
stirred fluid-loss cell
cell specially designed to allow for conditioning of the cement slurry within the same cell used to perform a static fluid loss test

3.1.48
strength retrogression
reduction in compressive strength and increase in permeability of a cement caused by exposure to temperatures exceeding 110 °C (230 °F)

3.1.49
thickening time
time required for a cement slurry to develop a selected Bearden consistency value

NOTE The results of a thickening-time test provide an indication of the length of time a cement slurry can remain pumpable under the test conditions.

3.1.50
weigh batch mixer
scale tank
device or system for the weighing and blending of cement with dry additives

3.1.51
well simulation test
test whose parameters are designed and modified as required to simulate the conditions found in a wellbore

3.2 Symbols

For the purposes of this part of ISO 10426, the symbols given in Table 1 apply. This list is non-exhaustive.

Table 1 — Symbols

Symbol	Meaning
h_{TOCTVD}	top-of-cement true vertical depth
p_{BH}	bottom-hole pressure[b]
p_S	starting pressure
p_{TOC}	top-of-cement pressure
T_{AS}	assumed surface temperature
T_{BHC}	bottom-hole circulating temperature[a]
T_{BHS}	bottom-hole static temperature
T_{PBHC}	predicted bottom-hole circulating temperature
T_{MRBHS}	maximum recorded bottom-hole temperature after a static period
T_{MNRBHC}	minimum recorded bottom-hole temperature after sufficient circulation in the well to obtain a stabilized or steady-state temperature
T_{PS}	predicted squeeze temperature
∇_{PT}	pseudo-temperature gradient[c]
T_{PU}	pseudo-undisturbed temperature
T_{RS}	recorded squeeze temperature
T_{SS}	slurry surface temperature
T_{TOCC}	top-of-cement circulating temperature
T_{TOCS}	top-of-cement static temperature
T_{TOC}	top-of-cement column temperature
T_{UF}	undisturbed formation temperature
t_a	time to displace the leading edge of the cement slurry from bottom of the casing to the top of the annular cement column
t_d	time to displace the leading edge of cement slurry to the bottom of the wellbore or other predetermined location in the well

a The T_{BHC} can vary with time, fluid being circulated, pump rate, pipe size, etc.

b Hydrostatic pressure at the bottom of the well, calculated from the true vertical depth and the fluid densities in the wellbore.

c Gradient in °C/100 m (°F/100 ft), calculated from the difference between the maximum recorded bottom-hole static temperature (T_{MRBHS}) and the T_{AS}.