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

Part 1: Specification

Industries du pétrole et du gaz naturel — Ciments et matériaux pour la cimentation des puits —
Partie 1: Spécification

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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 10426-1 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*.

This third edition cancels and replaces the second edition (ISO 10426-1:2005), which has been technically revised.

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

This part of ISO 10426 is based on ISO 10426-1:2005 with the intent that the 24th edition of API Spec 10A will be identical to this part of ISO 10426.

It is necessary that users of this part of ISO 10426 be aware that further or differing requirements can be required 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, it is the responsibility of the vendor to identify any variations from this part of ISO 10426 and provide details.

In this part of ISO 10426, where practical, US Customary (USC) or other units are included in brackets for information. The units do not necessarily represent a direct conversion of SI to USC units, or USC to SI. Consideration has been given to the precision of the instrument making the measurement. For example, thermometers are typically marked in 1° increments, thus temperature values have been rounded to the nearest degree.

In this part of ISO 10426, calibrating an instrument refers to assuring the accuracy of the measurement. Accuracy is the degree of conformity of a measurement 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 will 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.

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

Part 1: Specification

1 Scope

This part of ISO 10426 specifies requirements and gives recommendations for six classes of well cements, including their chemical and physical requirements and procedures for physical testing.

This part of ISO 10426 is applicable to well cement classes A, B, C and D, which are the products obtained by grinding Portland cement clinker and, if needed, calcium sulfate as an interground additive. Processing additives can be used in the manufacture of cement of these classes. Suitable set-modifying agents can be interground or blended during manufacture of class D cement.

This part of ISO 10426 is also applicable to well cement classes G and H, which are the products obtained by grinding clinker with no additives other than one or more forms of calcium sulfate, water or chemical additives as required for chromium (VI) reduction.

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 3310-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 13500, *Petroleum and natural gas industries — Drilling fluid materials — Specifications and tests*

ISO 24450, *Laboratory glassware — Wide-necked boiling flasks*

ASTM C109/C109M, *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or [50-mm] Cube Specimens)*

ASTM C115, *Standard Test Method for Fineness of Portland Cement by the Turbidimeter*

ASTM C465, *Standard Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements*

ASTM E1404-94(2008), *Standard Specification for Laboratory Glass Conical Flasks*

EN 196-1, *Methods of testing cement — Part 1: Determination of strength*

EN 196-2, *Methods of testing cement — Part 2: Chemical analysis of cement*

EN 196-6, *Methods of testing cement — Part 6: Determination of fineness*

EN 196-7, *Methods of testing cement — Part 7: Methods of taking and preparing samples of cement*

3 Terms and definitions

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

3.1
additive
material added to a cement slurry to modify or enhance some desired property

NOTE Properties that are commonly modified include setting time (by use of retarders or accelerators), fluid loss, viscosity, etc.

3.2
atmospheric pressure consistometer
device used for stirring and conditioning the cement slurry

NOTE The device is not intended to measure thickening time.

3.3
Bearden unit of consistency
B_c
measure of the consistency of a cement slurry when determined on a pressurized consistometer

3.4
cement
Portland cement
ground clinker generally consisting of hydraulic calcium silicates and aluminates and usually containing one or more forms of calcium sulfate as an interground additive

3.5
cement class
designation achieved under the ISO system for classification of well cement according to its intended use

3.6
cement grade
designation achieved under the ISO system for denoting the sulfate resistance of a particular cement

3.7
cement blend
mixture of dry cement and other dry materials

3.8
clinker
fused materials produced in the kiln during cement manufacturing that are interground with calcium sulfate to make cement

3.9
compressive strength
force per unit area required to cause a set cement sample to fail under compression

3.10
consistometer
device used to measure the thickening time of a cement slurry under temperature and under pressure

3.11
filtrate
liquid that is forced out of a cement slurry during a fluid loss test

3.12
free fluid
coloured or colourless liquid that separates from a cement slurry under static conditions

3.13
slurry container
slurry cup
container in an atmospheric or pressurized consistometer used to hold the slurry for conditioning purposes or for the thickening-time test

3.14
thickening time
time after which the consistency of a cement slurry has become so high that the slurry is considered unpumpable

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

4 Requirements

4.1 Specification, chemical and physical requirements

4.1.1 Classes and grades

4.1.1.1 General

Well cement shall be specified using classes A, B, C, D, G and H and the grades: ordinary (O), moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR).

A well cement that has been manufactured and supplied in accordance with this part of ISO 10426 may be mixed and placed in the field using water ratios or additives at the user's discretion. It is not intended that manufacturing compliance with this part of ISO 10426 be based on such field conditions.

Processing additives, set modifying agents or chemical additives used to reduce chromium (VI) shall not prevent a well cement from performing its intended functions.

4.1.1.2 Class A

This product is obtained by grinding clinker, consisting essentially of hydraulic calcium silicates, usually containing one or more forms of calcium sulfate as an interground additive. At the option of the manufacturer, processing additives may be used in the manufacture of class A cement, provided that such materials in the amounts used have been shown to meet the requirements of ASTM C465.

This product is intended for use when special properties are not required and is available only in O grade, similar to ASTM C150, type I.

4.1.1.3 Class B

This product is obtained by grinding clinker, consisting essentially of hydraulic calcium silicates, usually containing one or more forms of calcium sulfate as an interground additive. At the option of the manufacturer, processing additives may be used in the manufacture of class B cement, provided that such materials in the amounts used have been shown to meet the requirements of ASTM C465.

This product is intended for use when conditions require moderate or high sulfate resistance and is available in both MSR and HSR grades, similar to ASTM C150, type II.

4.1.1.4 Class C

This product is obtained by grinding clinker, consisting essentially of hydraulic calcium silicates, usually containing one or more forms of calcium sulfate as an interground additive. At the option of the manufacturer, processing additives may be used in the manufacture of class C cement, provided that such materials in the amounts used have been shown to meet the requirements of ASTM C465.

This product is intended for use when conditions require high, early strength and is available in O, MSR and HSR grades, similar to ASTM C150, type III.

4.1.1.5 Class D

This product is obtained by grinding clinker, consisting essentially of hydraulic calcium silicates, usually containing one or more forms of calcium sulfate as an interground additive. At the option of the manufacturer, processing additives may be used in the manufacture of class D cement, provided that such materials in the amounts used have been shown to meet the requirements of ASTM C465. Further, at the option of the manufacturer, suitable set-modifying agents may be interground or blended during manufacture.

This product is intended for use under conditions of moderately high temperatures and pressures and is available in MSR and HSR grades.

4.1.1.6 Class G

This product is obtained by grinding clinker, consisting essentially of hydraulic calcium silicates, usually containing one or more forms of calcium sulfate as an interground additive. No additives other than calcium sulfate or water, or both, shall be interground or blended with the clinker during manufacture of class G well cement.

This product is intended for use as a basic well cement and is available in MSR and HSR grades.

4.1.1.7 Class H

This product is obtained by grinding clinker, consisting essentially of hydraulic calcium silicates, usually containing one or more forms of calcium sulfate as an interground additive. No additives other than calcium sulfate or water, or both, shall be interground or blended with the clinker during manufacture of class H well cement.

This product is intended for use as a basic well cement and is available in MSR and HSR grades.

4.1.2 Chemical requirements

Well cements shall conform to the respective chemical requirements of classes and grades referenced in Table 1. It is not intended that this manufacturing compliance be applicable to field conditions. This part of ISO 10426 is not applicable to the use of cements that do not conform to the chemical requirements of classes and grades as set forth in Table 1.

Chemical analyses of hydraulic cements shall be carried out as specified in EN 196-2.

NOTE For the purposes of this provision, ASTM C114 is equivalent to EN 196-2.

Table 1 — Chemical requirements

	Cement class					
	A	B	C	D	G	H
Ordinary grade (O)						
Magnesium oxide (MgO), maximum, percent	6,0	NA[a]	6,0	NA	NA	NA
Sulfur trioxide (SO_3), maximum, percent[b]	3,5	NA	4,5	NA	NA	NA
Loss on ignition, maximum, percent	3,0	NA	3,0	NA	NA	NA
Insoluble residue, maximum, percent	0,75	NA	0,75	NA	NA	NA
Tricalcium aluminate (C_3A), maximum, percent[d]	NR[c]	NA	15	NA	NA	NA
Moderate sulfate-resistant grade (MSR)						
Magnesium oxide (MgO), maximum, percent	NA	6,0	6,0	6,0	6,0	6,0
Sulfur trioxide (SO_3), maximum, percent[b]	NA	3,0	3,5	3,0	3,0	3,0
Loss on ignition, maximum, percent	NA	3,0	3,0	3,0	3,0	3,0
Insoluble residue, maximum, percent	NA	0,75	0,75	0,75	0,75	0,75
Tricalcium silicate (C_3S) maximum, percent[d]	NA	NR	NR	NR	58	58
minimum, percent[d]	NA	NR	NR	NR	48	48
Tricalcium aluminate (C_3A), maximum percent[d]	NA	8	8	8	8	8
Total alkali content, expressed as sodium oxide (Na_2O) equivalent, maximum, percent[e]	NA	NR	NR	NR	0,75	0,75
High sulfate-resistant grade (HSR)						
Magnesium oxide (MgO), maximum, percent	NA	6,0	6,0	6,0	6,0	6,0
Sulfur trioxide (SO_3), maximum, percent[b]	NA	3,0	3,5	3,0	3,0	3,0
Loss on ignition, maximum, percent	NA	3,0	3,0	3,0	3,0	3,0
Insoluble residue, maximum, percent	NA	0,75	0,75	0,75	0,75	0,75
Tricalcium silicate (C_3S) maximum, percent[d]	NA	NR	NR	NR	65	65
minimum, percent[d]	NA	NR	NR	NR	48	48
Tricalcium aluminate (C_3A), maximum, percent[d]	NA	3	3	3	3	3
Tetracalcium aluminoferrite (C_4AF) plus twice the tricalcium aluminate (C_3A), maximum, percent[d]	NA	24	24	24	24	24
Total alkali content expressed as sodium oxide (Na_2O) equivalent, maximum, percent[e]	NA	NR	NR	NR	0,75	0,75

[a] NA indicates “not applicable”.

[b] When the tricalcium aluminate content (expressed as C_3A) of the cement is 8 % or less, the maximum SO_3 content shall be 3 %, or 3,5 % for class C cement.

[c] NR indicates “no requirement”.

[d] The expressing of chemical limitations by means of calculated assumed compounds does not necessarily mean that the oxides are actually or entirely present as such compounds. The compounds are calculated according to the ratio of the mass percentages of Al_2O_3 to Fe_2O_3, where w is the percentage mass fraction of the compound indicated in the subscript:

— When $w_{Al_2O_3}/w_{Fe_2O_3}$ is greater than 0,64, the compounds shall be calculated as follows:

$C_3A = 2{,}65w_{Al_2O_3} - 1{,}69w_{Fe_2O_3}$

$C_3S = 4{,}07w_{CaO} - 7{,}60w_{SiO_2} - 6{,}72w_{Al_2O_3} - 1{,}43w_{Fe_2O_3} - 2{,}85w_{SO_3}$

$C_4AF = 3{,}04w_{Fe_2O_3}$

— When $w_{Al_2O_3}/w_{Fe_2O_3}$ is 0,64 or less, the C_3A content is zero.

— The C_3S and C_4AF shall be calculated as follows:

$C_3S = 4{,}07w_{CaO} - 7{,}60w_{SiO_2} - 4{,}48w_{Al_2O_3} - 2{,}86w_{Fe_2O_3} - 2{,}85w_{SO_3}$

$C_4AF = 3{,}04w_{Fe_2O_3}$

[e] The sodium oxide equivalent, expressed as Na_2O equivalent, shall be calculated by the formula:

Na_2O equivalent is equal to $0{,}658w_{K_2O} + w_{Na_2O}$.

4.1.3 Physical and performance requirements

Well cement shall conform to the respective physical and performance requirements specified in Table 2 and in Clauses 6 through 10.

Table 2 — Summary of physical and performance requirements

Well cement class				**A**	**B**	**C**	**D**	**G**	**H**
Mix water, % mass fraction of cement (Table 5)				46	46	56	38	44	38
Fineness tests (alternative methods) (Clause 6)									
Turbidimeter (specific surface, minimum, m^2/kg)				150	160	220	NR[a]	NR	NR
Air permeability (specific surface, minimum, m^2/kg)				280	280	400	NR	NR	NR
Free-fluid content, maximum, percent (Clause 8)				NR	NR	NR	NR	5,9	5,9
Compressive strength test (8 h curing time)	**Schedule number** Table 6	**Final curing temperature** °C (°F)	**Curing pressure** MPa (psi)	**Minimum compressive strength** MPa (psi)					
(Clause 9)	NA[b]	38 (100)	atm.	1,7 (250)	1,4 (200)	2,1 (300)	NR	2,1 (300)	2,1 (300)
(Clause 9)	NA	60 (140)	atm.	NR	NR	NR	NR	10,3 (1 500)	10,3 (1 500)
(Clause 9)	6S	110 (230)	20,7 (3 000)	NR	NR	NR	3,4 (500)	NR	NR
Compressive strength test (24 h curing time)	**Schedule number** (Table 6)	**Final curing temperature** °C (°F)	**Curing pressure** MPa (psi)	**Minimum compressive strength** MPa (psi)					
(Clause 9)	NA	38 (100)	atm.	12,4 (1 800)	10,3 (1 500)	13,8 (2 000)	NR	NR	NR
(Clause 9)	4S	77 (170)	20,7 (3 000)	NR	NR	NR	6,9 (1 000)	NR	NR
(Clause 9)	6S	110 (230)	20,7 (3 000)	NR	NR	NR	13,8 (2 000)	NR	NR
Thickening-time test	**Specification test schedule number** Tables 9 through 11	**Maximum consistency** (15 min to 30 min stirring period) B_c[c]		**Thickening time** (minimum/maximum) min					
(Clause 10)	4	30		90[d]	90[d]	90[d]	90[d]	NR	NR
(Clause 10)	5	30		NR	NR	NR	NR	90[d]	90[d]
(Clause 10)	5	30		NR	NR	NR	NR	120[e]	120[e]
(Clause 10)	6	30		NR	NR	NR	100[d]	NR	NR

[a] NR indicates “no requirement”.

[b] NA indicates “not applicable”.

[c] Bearden units of consistency, B_c, obtained on a pressurized consistometer as defined in Clause 10 and calibrated in accordance with the same clause.

[d] Minimum thickening time.

[e] Maximum thickening time.

4.2 Sampling frequency, timing of tests, and equipment

4.2.1 Sampling frequency

4.2.1.1 For well cement classes C, D, G, and H, a sample for testing shall be taken by either of the following methods:

a) over an interval of 24 h;

b) on a 1 000 ton (maximum) production run.

4.2.1.2 For well cement classes A and B, a sample for testing shall be taken by either of the following methods:

a) over a 14-day interval;

b) on a 25 000 ton (maximum) production run.

4.2.1.3 These samples shall represent the product as produced. At the choice of the manufacturer, either sampling method may be used.

4.2.2 Time from sampling to testing

Each sample shall be tested for conformance to this part of ISO 10426. All tests shall be completed within seven working days after sampling.

4.2.3 Specified equipment

Equipment used for testing well cements shall comply with Table 3. Dimensions shown in Figures 5 through 7 and Figures 10 through 12 are for the purposes of manufacturing the cement-specification test equipment. Dimensional recertification is not required.

4.2.4 Calibration

Equipment calibrated in accordance with the requirements of this part of ISO 10426 is considered accurate if the calibration is within the specified limits.

Table 3 — Specification test equipment for well-cement manufacturers

Test or preparation	Well cement classes	Clause reference	Required equipment
Sampling	All	5	Apparatus as specified in EN 196-7 NOTE For the purposes of this provision, ASTM C183 is equivalent to EN 196-7.
Fineness	A, B, C	6	Turbidimeter and auxiliary equipment as specified in ASTM C115 or air permeability apparatus and auxiliary equipment as specified in EN 196-6. NOTE For the purposes of this provision, ASTM C204 is equivalent to EN 196-6.
Slurry preparation	All	7	Apparatus as specified in 7.1
Free fluid	G, H	8	Apparatus as specified in 8.1
Atmospheric pressure compressive strength	A, B, C, G, H	9	Apparatus as specified in 9.1, except pressure vessel of 9.1.3.2
Pressure cured compressive strength	D	9	Apparatus as specified in 9.1,except curing bath of 9.1.3.3
Thickening time	All	10	Pressurized consistometer specified in 10.1