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

Part 1: Specification

Industrie du pétrole et du gaz naturel — Ciments et matériaux de cimentation des puits —

Partie 1: Spécifications

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Foreword

ISO (the International Organisation for Standardisation) 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 organisations, 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 standardisation.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 10426 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10426-1 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum 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: Recommended practice for testing of well cement*

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

Introduction

This part of ISO 10426 is based on API Specification 10A, 22nd edition, January 1995.

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, U.S. Customary units are included in brackets for information.

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 eight 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, D, E and F, which are the products obtained by grinding Portland cement clinker and, if needed, calcium sulfate as an interground additive. Processing additives may be used in the manufacture of cement of these classes. Suitable set-modifying agents may be interground or blended during manufacture of Classes D, E and F.

This part of ISO 10426 is also applicable to well cement Classes G and H, which are the products obtained by grinding Portland cement clinker with no additives other than calcium sulfate or water.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10426. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10426 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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.*

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

ASTM C 114, *Standard test methods for chemical analysis of hydraulic cement.*

ASTM C 115, *Standard test methods for fineness of Portland cement by the turbidimeter .*

ASTM C 183, *Standard practice for sampling and the amount of testing of hydraulic cement.*

ASTM C 204, *Standard test method for fineness of Portland cement by air permeability apparatus.*

ASTM C 465, *Standard specification for processing additions for use in the manufacture of hydraulic cements.*

ASTM E 220, *Standard test method for calibration of thermocouples by comparison techniques.*

ASTM E 1404, *Standard specification for laboratory class conical flasks.*

DIN 12385, *Laboratory glassware, conical flasks, wide neck.*

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.*

EN 196-21, *Methods of testing cement — Part 21: Determination of the chloride, carbon dioxide and alkali content of cement.*

3 Terms and definitions

For the purposes of this part of ISO 10426, 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
Bearden unit of consistency
B_c
measure of the consistency of a cement slurry when determined on a pressurized consistometer

3.3
bulk density
mass per unit volume of a dry material containing entrained air

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 using the ISO system of classification of well cement according to its intended use

3.6
cement grade
designation achieved using 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 from the kiln in cement manufacturing that are interground with calcium sulfate to make cement

3.9
compressive strength
force per unit area required to crush a set cement sample

3.10
consistometer
device used to measure the thickening time of a cement slurry under temperature and 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 which has separated from a cement slurry

3.13
neat cement slurry
cement slurry consisting of only cement and water

3.14
pressure vessel
vessel in a consistometer into which the slurry container is placed for the thickening time test

3.15
slurry container
slurry cup
container in a pressurized consistometer used to hold the slurry for conditioning purposes or for the thickening time test

3.16
thickening time
time for a cement slurry to develop a selected B_c

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

4 Requirements

4.1 Specification, chemical and physical requirements

4.1.1 Classes and grades

Well cement shall be specified using the following Classes (A, B, C, D, E, F, G and H) and Grades (O, MSR and HSR).

A processing additive or set-modifying agent shall not prevent a well cement from performing its intended functions.

a) **Class A**

The product obtained by grinding Portland cement 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 such materials in the amounts used have been shown to meet the requirements of ASTM C 465.

This product is intended for use when special properties are not required. Available only in ordinary (O) Grade (similar to ASTM C 150, Type I).

b) **Class B**

The product obtained by grinding Portland cement 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 such materials in the amounts used have been shown to meet the requirements of ASTM C 465.

This product is intended for use when conditions require moderate or high sulfate-resistance. Available in both moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades (similar to ASTM C 150, Type II).

c) **Class C**

The product obtained by grinding Portland cement 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 such materials in the amounts used have been shown to meet the requirements of ASTM C 465.

This product is intended for use when conditions require high early strength. Available in ordinary (O), moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades (similar to ASTM C 150, Type III).

d) **Class D**

The product obtained by grinding Portland cement 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 such materials in the amounts used have been shown to meet the requirements of ASTM C 465. 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. Available in moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades.

e) **Class E**

The product obtained by grinding Portland cement 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 E cement, provided such materials in the amounts used have been shown to meet the requirements of ASTM C 465. 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 high temperatures and pressures. Available in moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades.

f) **Class F**

The product obtained by grinding Portland cement 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 F cement, provided such materials in the amounts used have been shown to meet the requirements of ASTM C 465. 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 extremely high temperatures and pressures. Available in moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades.

g) **Class G**

The product obtained by grinding Portland cement 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. Available in moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades.

h) **Class H**

The product obtained by grinding Portland cement 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. Available in moderate sulfate-resistant (MSR) and high sulfate-resistant (HSR) Grades.

A well cement which 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.

4.1.2 Chemical requirements

Well cements shall conform to the respective chemical requirements of classes and grades referenced in Table 1.

Chemical analyses of hydraulic cements shall be carried out as specified in ASTM C 114 (or EN 196-2, EN 196-21).

4.1.3 Physical and performance requirements

Well cement shall conform to the respective physical and performance requirements referenced in Table 2 and specified in clauses 6, 7, 8, 9 and 10.

Table 1 — Chemical requirements

	Cement Class					
	A	**B**	**C**	**D, E, F**	**G**	**H**
ORDINARY GRADE (O)						
Magnesium oxide (MgO), maximum, %	6,0	NA	6,0	NA	NA	NA
Sulfur trioxide (SO_3), maximum, %	3,5 [a]	NA	4,5	NA	NA	NA
Loss on ignition, maximum, %	3,0	NA	3,0	NA	NA	NA
Insoluble residue, maximum, %	0,75	NA	0,75	NA	NA	NA
Tricalcium aluminate (C_3A), maximum, %	NR	NA	15	NA	NA	NA
MODERATE SULFATE-RESISTANT GRADE (MSR)						
Magnesium oxide (MgO), maximum, %	NA	6,0	6,0	6,0	6,0	6,0
Sulfur trioxide (SO_3), maximum, %	NA	3,0	3,5	3,0	3,0	3,0
Loss on ignition, maximum, %	NA	3,0	3,0	3,0	3,0	3,0
Insoluble residue, maximum, %	NA	0,75	0,75	0,75	0,75	0,75
Tricalcium silicate (C_3S) maximum, %	NA	NR	NR	NR	58 [b]	58 [b]
minimum, %	NA	NR	NR	NR	48 [b]	48 [b]
Tricalcium aluminate (C_3A), maximum % (3)	NA	8	8	8	8	8
Total alkali content, expressed as sodium oxide (Na_2O) equivalent, maximum, %	NA	NR	NR	NR	0,75 [c]	0,75 [c]
HIGH SULFATE-RESISTANT GRADE (HSR)						
Magnesium oxide (MgO), maximum, %	NA	6,0	6,0	6,0	6,0	6,0
Sulfur trioxide (SO_3), maximum, %	NA	3,0	3,5	3,0	3,0	3,0
Loss on ignition, maximum, %	NA	3,0	3,0	3,0	3,0	3,0
Insoluble residue, maximum, %	NA	0,75	0,75	0,75	0,75	0,75
Tricalcium silicate (C_3S) maximum, %	NA	NR	NR	NR	65 [b]	65 [b]
minimum, %	NA	NR	NR	NR	48 [b]	48 [b]
Tricalcium aluminate (C_3A), maximum, %	NA	3 [b]	3 [b]	3 [b]	3 [b]	3 [b]
Tetracalcium aluminoferrite (C_4AF) plus twice the tricalcium aluminate (C_3A), maximum, %	NA	24 [b]	24 [b]	24 [b]	24 [b]	24 [b]
Total alkali content expressed as sodium oxide (Na_2O) equivalent, maximum, %	NA	NR	NR	NR	0,75 [c]	0,75 [c]

NR = No Requirement; NA = Not Applicable

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

[b] 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. When the ratio of the percentages of Al_2O_3 to Fe_2O_3 is 0,64 or less, the C_3A content is zero. When the Al_2O_3 to Fe_2O_3 ratio is greater than 0,64, the compounds shall be calculated as follows:

$C_3A = (2{,}65 \times \%\ Al_2O_3) - (1{,}69 \times \%\ Fe_2O_3)$

$C_4AF = 3{,}04 \times \%\ Fe_2O_3$

$C_3S = (4{,}07 \times \%\ CaO) - (7{,}60 \times \%\ SiO_2) - (6{,}72 \times \%\ Al_2O_3) - (1{,}43 \times \%\ Fe_2O_3) - (2{,}85 \times \%\ SO_3)$

When the ratio of Al_2O_3 to Fe_2O_3 is less than 0,64, the C_3S shall be calculated as follows:

$C_3S = (4{,}07 \times \%\ CaO) - (7{,}60 \times \%\ SiO_2) - (4{,}48 \times \%\ Al_2O_3) - (2{,}86 \times \%\ Fe_2O_3) - (2{,}85 \times \%\ SO_3)$

[c] The sodium oxide equivalent (expressed as Na_2O equivalent) shall be calculated by the formula:

Na_2O equivalent = $(0{,}658 \times \%\ K_2O) + (\%\ Na_2O)$

Table 2 — Summary of physical and performance requirements

Well cement Class				**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Mix water, % mass fraction of cement (Table 5)				46	46	56	38	38	38	44	38
Fineness tests (alternative methods) (clause 6)											
Turbidimeter (specified surface, minimum m^2/kg)				150	160	220	NR	NR	NR	NR	NR
Air permeability (specified surface, minimum m^2/kg)				280	280	400	NR	NR	NR	NR	NR
Free fluid content, maximum % (clause 8)				NR	NR	NR	NR	NR	NR	5,5	5,5
Compressive strength test (8-h curing time) (clause 9)	**Schedule number, Table 6**	**Final curing temp.** °C (°F)	**Final curing pressure** MPa (psi)	**Minimum compressive strength** MPa (psi)							
	NA	38 (100)	atm.	1,7 (250)	1,4 (200)	2,1 (300)	NR	NR	NR	2,1 (300)	2,1 (300)
	NA	60 (140)	atm.	NR	NR	NR	NR	NR	NR	10,3 (1 500)	10,3 (1 500)
	6S	110 (230)	20,7 (3 000)	NR	NR	NR	3,4 (500)	NR	NR	NR	NR
	8S	143 (290)	20,7 (3 000)	NR	NR	NR	NR	3,4 (500)	NR	NR	NR
	9S	160 (320)	20,7 (3 000)	NR	NR	NR	NR	NR	3,4 (500)	NR	NR
Compressive strength test (24-h curing time) (clause 9)	**Schedule number, Table 6**	**Final curing temp.** °C (°F)	**Final curing pressure** MPa (psi)	**Minimum compressive strength** MPa (psi)							
	NA	38 (100)	Atm.	12,4 (1 800)	10,3 (1 500)	13,8 (2 000)	NR	NR	NR	NR	NR
	4S	77 (170)	20,7 (3 000)	NR	NR	NR	6,9 (1 000)	6,9 (1 000)	NR	NR	NR
	6S	110 (230)	20,7 (3 000)	NR	NR	NR	13,8 (2 000)	NR	6,9 (1 000)	NR	NR
	8S	143 (290)	20,7 (3 000)	NR	NR	NR	NR	13,8 (2 000)	NR	NR	NR
	9S	160 (320)	20,7 (3 000)	NR	NR	NR	NR	NR	6,9 (1 000)	NR	NR