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BLAST FURNACE CEMENT CEM III/A WITH ASSESSMENT OF SULFATE RESISTANCE (SR) AND OPTIONAL WITH LOW EFFECTIVE ALKALI CONTENT (LA) AND/OR LOW HEAT OF HYDRATION (LH)

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The "Blast furnace cement CEM III/A with assessment of sulfate resistance (SR) and optional low heat of hydration (LH) and/or with a low effective alkali content (LA)" fulfils all requirements of a blast furnace cement CEM III/A according to EN 197-1[1] for a common cement and if applicable low heat of hydration. In the further text the product "Blast furnace cement CEM III/A with assessment of sulfate resistance (SR) and optional low heat of hydration (LH) and/or with a low effective alkali content (LA)" is replaced by the designation "Blast furnace cement CEM III/A (SR/LH/LA)".

Additionally, to a common cement the "Blast furnace cement CEM III/A (SR/LH/LA)" has a high resistance against sulfate attack on concrete (SR) and optionally also a low heat of hydration (LH) and/or a low effective alkali content (LA), which is not covered by EN 197-1.

To achieve a high sulfate resistance a minimum content of granulated blast furnace slag is specified (S_{min}), which is higher compared to the value given in EN 197-1 for a CEM III/A. A maximum content of minor additional constituents (MAC_{max}) ≤ 5 % by mass can be added. For the determination of the maximum clinker content the maximum content of minor additional constituents shall be considered ($K = 100-S_{min}-MAC_{max}$).

In addition, the specific surface (Blaine) of the cement is an essential characteristic of high sulfate resistance, which must be adjusted depending on the manufacturing process and the assessment testing.

The assessment shall be carried out on a fixed cement composition (constituents (Portland cement clinker K_{max}, blast furnace slag S_{min} and minor additional constituents MAC_{max}) and composition), fineness of the cement and the manufacturing process. If one of the aforementioned factors is modified a new assessment is required.

The low effective alkali content (LA) of the "Blast furnace cement CEM III/A (SR/LH/LA)" is covered by the Na_2O-equivalent of the "Blast furnace cement CEM III/A (SR/LH/LA)" and the granulated blast furnace content:

S_{min}: 45 to 49 % by mass and Na_2Oeq ≤ 0,95 % by mass

S_{min}: ≥ 50 % by mass and Na_2Oeq ≤ 1,10 % by mass

The "Blast furnace cement CEM III/A (SR/LH/LA)" is not fully covered by the following harmonised technical specification: EN 197-1.

In table 1.1.1 the differences between "Blast furnace cement CEM III/A (SR/LH/LA)" and a Blast furnace cement CEM III/A according to EN 197-1 are listed.

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1 All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in clause 4.

Table 1.1.1: Comparison between cement composition, specifications and characteristics of EN 197-1

"Blast furnace cement CEM III/A (SR/LH/LA)"	Specifications of EN 197-1 (CEM III/A)
Selected and defined granulated blast furnace slag with glass content ≥ 90 % by mass and ratio by mass $(CaO+MgO)/SiO_2$ [2] ≥ 1,2	Clause 5.2.2: glass content ≥ 66 % by mass and ratio by mass $(CaO+MgO)/SiO_2$ ≥ 1,0
Content of blast furnace slag ≥ 45 % by mass	Clause 6.1, Table 1: Content of blast furnace slag ≥ 36 % by mass and ≤ 65 % by mass
Strength class ≥ 32,5 N	No requirement
Low effective alkali content (LA):	Specifications of EN 197-1 (CEM III/A)
- content of blast furnace slag 45 to 49 % by mass: Na_2Oeq ≤ 0,95 % by mass	Clause 7.3: no requirement
- content of blast furnace slag 50 % by mass: Na_2Oeq ≤ 1,10 % by mass	Clause 7.3: no requirement

This EAD version covers the following amendment in comparison to version 00: The strength class for "Blast furnace cement CEM III/A (SR/LH/LA)" has been extended to include the strength classes 32,5 N, 32,5 R and 42,5 L.

For this reason, clauses 2.2.2 "Early (compressive) strength (2 days or 7 days)", 2.2.3 "Standard (compressive) strength (28 days)", 2.2.4 "Initial setting time", 3.2 "Tasks of the manufacturer " (table 3.2.1) and 3.3 "Tasks of the notified body" (table 3.3.1) had to be adjusted.

The clauses 2.2.1 "$(CaO + MgO)/SiO_2$-ratio of the granulated blast furnace slag", 2.2.2 "Glass content of the granulated blast-furnace" and 2.2.13 "Composition of cement" were shifted to clause 3.4 "Special methods of control and testing used for the assessment and verification of constancy of performance".

In addition, the document was editorially revised.

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the "Blast furnace cement CEM III/A (SR/LH/LA)" will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the "Blast furnace cement CEM III/A (SR/LH/LA)" covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The "Blast furnace cement CEM III/A (SR/LH/LA)" is intended to be used for preparation of concrete, mortar, grouts and other mixes for construction and for the manufacturing of construction products.

Especially the "Blast furnace cement CEM III/A (SR/LH/LA)" is characterized by an evidently high resistance against sulfate attack on concrete and in case for the characteristic "LA" to prevent a damaging alkali silica reaction in the concrete.

[2] Ratio by mass $(CaO+MgO)/SiO_2$ = Basicity (B)

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of concrete incorporating the "Blast furnace cement CEM III/A (SR/LH/LA)" for the intended use of 50 years when installed in the works provided that the "Blast furnace cement CEM III/A (SR/LH/LA)" is subject to appropriate installation (see clause 1.1). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[3].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD (if necessary in addition to the definitions in CPR, Art 2)

The notations and symbols frequently used in this EAD are given below. Further particular notation and symbols are given in the text.

CH	=	Saturated Calciumhydroxide $Ca(OH)_2$
G	=	Glass content of the granulated blast furnace slag
K	=	Portland cement clinker according to EN 197-1
LA	=	Low effective alkali content
LH	=	Low heat of hydration
MAC	=	Minor additional constituents according to EN 197-1
NS	=	Natriumsulfate Na_2SO_4
S	=	Blast furnace slag according to EN 197-1
SR	=	High resistance against sulfate attack

Abbreviation and symbols:

Cl^-	=	Chloride content [% by mass]
$E_{d,0}$	=	Dynamic Modulus of Elasticity [kN/mm²] after pre-storage respectively before storage of the specimens in saturated $Ca(OH)_2$-solution and 4,4 % $Na_2(SO)_4$-solution
$E_{d,CH,(ti,T)}$	=	Dynamic Modulus of Elasticity [kN/mm²] after storage in saturated $Ca(OH)_2$-solution after a storage time t_i = 14, 28, 56, 91 and 182 days and storage temperature (T) of 5 °C and 20 °C
$E_{d,NS,(ti,T)}$	=	Dynamic Modulus of Elasticity [kN/mm²] after storage in 4,4 % $Na_2(SO)_4$-solution after a storage time t_i = 14, 28, 56, 91 and 182 days and storage temperature (T) of 5 °C and 20 °C
IR	=	Insoluble residue [% by mass]
IST	=	Initial setting time [min]
LOI	=	Loss on ignition content [% by mass]
$R_{c,2d}$	=	Compressive strength after 2 days [MPa or N/mm²]
$R_{c,7d}$	=	Compressive strength after 7 days [MPa or N/mm²]
$R_{c,28d}$	=	Compressive strength after 28 days [MPa or N/mm²]

[3] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

S	=	Soundness [mm]
SO_3	=	Sulfate content [% by mass]
T	=	Storage temperature [°C]
i	=	duration
l	=	length of the specimen [mm]
t_i	=	storage time [days]
w_0	=	weight of the specimen [g] after pre-storage after pre-storage respectively before storage of the specimens in saturated $Ca(OH)_2$-solution and 4,4 % $Na_2(SO)_4$-solution
$w_{CH(ti,T)}$	=	weight of the specimen [g] after storage in saturated $Ca(OH)_2$-solution after a storage time t_i = 14, 28, 56, 91 and 182 days and storage temperature (T) of 5 °C and 20 °C
$w_{NS(ti,T)}$	=	weight of the specimen [g] after storage in 4,4 % $Na_2(SO)_4$-solution after a storage time t_i = 14, 28, 56, 91 and 182 days and storage temperature (T) of 5 °C and 20 °C
$\Delta l_{CH(ti,T)}$	=	mean value of the length difference (storage in saturated $Ca(OH)_2$-solution after a storage time t_i = 14, 28, 56, 91 and 182 days and storage temperature (T) of 5 °C and 20 °C) of 3 specimens
$\Delta l_{NS(ti,T)}$	=	mean value of the length difference (storage in 4,4 % Na_2SO_4-solution after a storage time t_i = 14, 28, 56, 91 and 182 days and storage temperature (T) of 5 °C and 20 °C) of 3 specimens
$\Delta l_{ti,T}$	=	expansion [mm/m] after a storage time t_i = 14, 28, 56, 91 and 182 days at a storage temperature (T) of 5 °C and 20 °C
ρ	=	Specific surface (Blaine) [cm²/g]

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of "Blast Furnace Cement CEM III/A (SR/LH/LA)" is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Specific surface of the cement (Blaine)	2.2.1	Level (ρ [cm²/g])
2	Early (compressive) strength (2 days or 7 days)	2.2.2	Class ($R_{c,2d}$; $R_{c,7d}$ [MPa or N/mm²])
3	Standard (compressive) strength (28 days)	2.2.3	Class ($R_{c,28d}$ [MPa or N/mm²])
4	Initial setting time	2.2.4	Description (IST [min])
5	Soundness	2.2.5	Description (S [mm])
6	Loss on ignition	2.2.6	Description (LOI [% by mass])
7	Insoluble residue	2.2.7	Description (IR [% by mass])
8	Sulfate content (as SO_3)	2.2.8	Description (SO_3 [% by mass])
9	Chloride content	2.2.9	Description (Cl^- [% by mass])
10	Sulfate resistance (SR)	2.2.10	Description (graph; photos) and Level ($\Delta l_{NS(ti,T)}$; $\Delta l_{CH(ti,T)}$; $\Delta l_{ti,T}$: [mm/m]; $E_{d,NS,(ti,T)}$, $E_{d,CH,(ti,T)}$ and $E_{d,0}$: [kN/mm²]; $w_{NS(ti,T)}$, $w_{CH(ti,T)}$ and w_0: [g])
11	Alkali content of the cement (as Na_2O_{eq}) (LA)	2.2.11	Level (Na_2O_{eq} [% by mass])
12	Heat of hydration (LH)	2.2.12	Description (LH [J/g])
Basic Works Requirement 3: Content, emission and/or release of dangerous substances			
13	Water-soluble chromium (VI) content	2.2.13	Level [mg/kg]

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as "shall be stated in the ETA" or "has to be given in the ETA" shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Specific surface of the cement (Blaine)

The specific surface (Blaine) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined by the air permeability method specified in EN 196-6, clause 4.

The specific surface of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be given in the ETA.

2.2.2 Early (compressive) strength (2 days or 7 days)

The early compressive strength of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-1, clause 9.2, at a specimen age of 2 days for assessing strength classes 32,5 R, 42,5 N and higher or at a specimen age of 7 days for assessing strength classes 32,5 N or 42,5 L.

The three classes of early (compressive) strength depends on the 2 day or 7 day - compressive strength and shall be

	Compressive strength [MPa]	
	Early (compressive) strength	
Strength class	2 days	7 days
32,5 **N**	-	≥ 16
32,5 **R**	≥ 10	-
42,5 **L**	-	≥ 16
42,5 **N**	≥ 10	-
42,5 **R**	≥ 20	-
52,5 **L**	≥ 10	-
52,5 **N**	≥ 20	-
52,5 **R**	≥ 30	-

according to EN 197-1, clause 7.1, table 3.

The early (compressive) strength ($R_{c,2d}$) at 2 days or ($R_{c,7d}$) at 7 days and the class of early (compressive) strength (L, N or R) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.3 Standard (compressive) strength (28 days)

The standard (compressive) strength of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-1, clause 9.2, at a specimen age of 28 days.

The three classes of standard strength depend on the 28 day - compressive strength and shall be

Strength class	28 days-compressive strength [MPa]	
32,5 N	≥ 32,5	≤ 52,5
32,5 R		
42,5 L	≥ 42,5	≤ 62,5
42,5 N		
42,5 R		
52,5 L	≥ 52,5	-
52,5 N		
52,5 R		

according to EN 197-1, clause 7.1, table 3.

The standard (compressive) strength ($R_{c,28d}$) at 28 days and the class of standard (compressive) strength of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.4 Initial setting time

The initial setting time (IST) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-3, clause 6.

The initial setting time depends on the strength class of the cement (see clause 2.2.2 and clause 2.2.3) and shall be

Strength class	Initial setting time (IST)
32,5 N	≥ 75 min
32,5 R	
42,5 L	≥ 60 min
42,5 N	
42,5 R	
52,5 L	≥ 45 min
52,5 N	
52,5 R	

according to EN 197-1, clause 7.1, table 3.

The initial setting time (IST) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.5 Soundness

The soundness (expansion) (S) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-3, clause 7.

The soundness (expansion) (S) shall be less or equal than 10 mm according to EN 197-1, table 3.

The soundness (expansion) (S) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.6 Loss on ignition

The loss on ignition of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-2, clause 4.4.1.

The loss on ignition shall not exceed 5,0 % by mass according to EN 197-1, table 4. The loss on ignition of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.7 Insoluble residue

The insoluble residue of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-2, clause 4.4.3.

The insoluble residue shall not exceed 5,0 % by mass according to EN 197-1, table 4. The insoluble residue of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.8 Sulfate content (as SO_3)

The sulfate content (as SO_3), of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-2, clause 4.4.2.

The sulfate content (as SO_3) shall not exceed 4,0 % by mass according to EN 197-1, table 4. The sulfate content (as SO_3) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.9 Chloride content

The chloride content Cl^- of the "Blast Furnace Cement CEM III/A (SR/LH/LA)" is determined according to EN 196-2, clause 4.5.16.

The chloride content of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

Note:

The chloride content of "Blast Furnace Cement CEM III/A (SR/LH/LA)" may be greater than 0,10 % by mass but in that case the maximum chloride content shall be stated on the packaging and/or the delivery note, see note **e** in table 4 of EN 197-1.

For pre-stressing applications, the "Blast Furnace Cement CEM III/A (SR/LH/LA)" may be produced according to a lower requirement, see note **f** in table 4 of EN 197-1.

2.2.10 Sulfate resistance (SR)

The sulfate resistance of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined by the flat prism method (**S_{FPM}**) given in **Annex A** on mortar specimens aged up to 26 weeks in 4,4 % Na_2SO_4-solution and in saturated calcium hydroxide ($Ca(OH)_2$-solution.

The mean values of the length difference [mm/m] for each tested cement ("Blast Furnace cement CEM III/A (SR/LH/LA) and two reference cements (SR-cements according to EN 197-1)), test solution (4,4 % Na_2SO_4-solution and saturated $Ca(OH)_2$-solution), storage temperature (T = 5 °C and 20 °C) and storage time (t_i = 14, 28, 56, 91 and 182 days (182 days only for a storage at 20 °C)) shall be given in the ETA:

$\Delta l_{NS,(ti,T)}$

$\Delta l_{CH,(ti,T)}$

The calculated expansion of the length [mm/m] for each tested cement, storage temperature (T = 5 °C and 20 °C) and storage time (t_i = 14, 28, 56, 91 and 182 days (182 days only for storage at 20 °C)) shall be given in the ETA:

$\Delta l_{ti,T}$

The mean value of the dynamic modulus of elasticity for each tested cement, storage solution (4,4 % Na_2SO_4-solution and saturated $Ca(OH)_2$-solution), storage temperature (T = 5 °C and 20 °C) and storage time (t_i = 14, 28, 56, 91 and 182 days (182 days only for storage at 20 °C) and also the initial measurement (after pre-storage t = 0) shall be given in the ETA:

$E_{d,NS,(ti,T)}$, $E_{d,CH,(ti,T)}$ and $E_{d,0}$

The mean value of mass of the specimens for each tested cement, storage solution (4,4 % Na_2SO_4-solution and saturated $Ca(OH)_2$-solution), storage temperature (T = 5 °C and 20 °C) and storage time (t_i = 14, 28, 56, 91 and 182 days (182 days only for storage at 20 °C)) and also the initial measurement (after pre-storage t = 0) shall be given in the ETA:

$w_{NS,(ti,T)}$, $w_{CH,(ti,T)}$ and w_0

In addition, a detailed description of the specimens in view of cracks (e. g. photo) after testing – if any - shall be stated in the ETA.

2.2.11 Alkali content of the cement (as Na_2O_{eq}) (LA)

The chemical composition of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-2, clause 4.5.19.

The Na_2O_{eq} is calculated by the formula (36) according to EN 196-2, clause 4.5.19.6.2.

The alkali content (Na_2O_{eq}) of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.12 Heat of hydration (LH)

The heat of hydration of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-8 at 7 days.

The heat of hydration of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall not exceed the value of 270 J/g according to EN 197-1, clause 7.2.3.

The heat of hydration of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

2.2.13 Water-soluble chromium (VI) content

The water-soluble-chromium (VI) content of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to EN 196-10.

The content of water-soluble chromium (VI) in mg/kg of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be stated in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For "Blast Furnace Cement CEM III/A (SR/LH/LA)" covered by this EAD the applicable European legal act is Commission Decision 1997/555/EC[4] as amended by Commission Decision 2010/683/EU[5].

The system is 1+.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of "Blast Furnace Cement CEM III/A (SR/LH/LA)" in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Specific surface of the cement (Blaine)	2.2.1	Control plan	1	1/week [a] 2/month [b]
2	Early (compressive) strength (2 days or 7 days)	2.2.2	32,5 N ≥ 14,0 MPa 32,5 R ≥ 8,0 MPa 42,5 L ≥ 14,0 MPa 42,5 N ≥ 8,0 MPa 42,5 R ≥ 18,0 MPa 52,5 L ≥ 8,0 MPa 52,5 N ≥ 18,0 MPa 52,5 R ≥ 28,0 MPa lower limit value[1)] Class	1	4/week [a] 2/week [b]
3	Standard (compressive) strength (28 days)	2.2.3	32,5 N, 32,4 R ≥ 30,0 MPa 42,5 L, 42,5 N, 42,5 R ≥ 40,0 MPa 52,5 L, 52,5 N, 52,5 R ≥ 50,0 MPa lower limit value[1)] Class	1	
4	Initial setting time	2.2.4	≤ 10 mm upper limit value[1)]	1	
5	Soundness	2.2.5	32,5 N, 32,4 R ≥ 60 min 42,5 L, 42,5 N, 42,5 R ≥ 50 min 52,5 L, 52,5 N, 52,5 R ≥ 40 min lower limit value[1)]	1	4/week [a] 1/week [b]
6	Loss on ignition	2.2.6	Control plan	1	1/week [a] 2/month [b]
7	Insoluble residue	2.2.7	Control plan	1	
8	Sulfate content (as SO_3)	2.2.8	Control plan	1	4/week [a] 2/week [b]

[4] Official Journal of the European Communities L 229/9 of 20/08/1997, as amended 1by Commission Decision 2010/683/EU (Official Journal of the European Union L293 of 11/11/2010)

[5] Official Journal of the European Communities L 293 of 11 November 2010

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
9	Chloride content	2.2.9	≤ 0,10 % by mass upper limit vaule[1)]	1	1/week [a] 2/month [b, c]
10	Alkali content of the cement (Na_2O_{eq})	2.2.11	Control plan	1	4/week [a] 2/week [b]
11	Heat of hydration (LH)	2.2.12	≤ 300 min upper limit value[1)]	1	1/week [a] 1/month [b]
12	Water-soluble-chromium (VI) content	2.2.13	Control plan	1	1/week [a] 1/month [b]
13	Control of main constituents	3.4.1	Control plan	1	continuousl y
14	CaO + MgO)/SiO_2-ratio of the granulated blast furnace slag	3.4.2	Control plan	1	1/week [a] 1/month [b]
15	Glass content of the granulated blast furnace	3.4.3	Control plan	1	
16	Composition of "Blast furnace cement CEM III/A (SR/LH/LA)"	3.4.4	Control plan	1	1/week [a] 1/month [b]

1) Limit values for single results according to EN 197-1, table 10,

a Initial period for a new type of cement according to EN 197-1, table 6,

b Routine situation according to EN 197-1, table 6,

c When none of the test results within a period of 12 months exceeds 50 % of the characteristic value the frequency may be reduced to one per month according to EN 197-1.

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for "Blast Furnace Cement CEM III/A (SR/LH/LA)" are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	According to EN 197-2, clause 5.2	See FPC according to table 3.2.1	Control plan	-	1/year
Continuous surveillance, assessment and evaluation of factory production control					
2	According to EN 197-2, clause 5.3	See FPC according to table 3.2.1	Control plan	-	1/year
Audit-testing of samples taken by the notified product certification body at the manufacturing plant or at the manufacturer's storage facilities					
3	According to EN 197-2, clause 5.4 (see also table 3.2.1 (no. 1 to 16))	See FPC according to table 3.2.1	Control plan	1	6/year

3.4 Special methods of control and testing used for the assessment and verification of constancy of performance

3.4.1 Control of main constituents by manufacturer

The origin of the main constituents (clinker and granulated blast furnace slag) for the production of the "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be checked and documented.

3.4.2 (CaO + MgO)/SiO_2-ratio of the granulated blast furnace slag

The chemical composition of the granulated blast furnace slag shall be determined according to EN 196-2. The (CaO + MgO)/SiO_2-ratio (basicity) is calculated on the basis of the chemical composition.

3.4.3 Glass content of the granulated blast furnace

The glass content of the granulated blast furnace slag (G) shall be determined by the test method given in Annex B.

3.4.4 Composition of the Blast furnace cement CEM III/A

The composition of "Blast Furnace Cement CEM III/A (SR/LH/LA)" shall be determined according to CEN/TR 196-4 or by an appropriate assessment method, see EN 197-1, clause 9, Table 6, footnote i.

4 REFERENCE DOCUMENTS

CEN/TR 196-4:2007	Methods of testing cement - Part 4: Quantitative determination of constituents
EN 196-1:2016	Methods of testing cement - Part 1: Determination of strength
EN 196-2:2013	Methods of testing cement - Part 2: Chemical analysis of cement
EN 196-3:2016	Methods of testing cement - Part 3: Determination of setting time and soundness
EN 196-6:2018	Methods of testing cement - Part 6: Determination of fineness
EN 196-8:2010	Methods of testing cement - Part 8: Heat of hydration - Solution method
EN 196-10:2016	Methods of testing cement - Part 10: Determination of the water-soluble chromium content of cement
EN 197-1:2011	Cement - Part 1: Composition, specification and conformity criteria for common cements
EN 197-2:2020	Cement - Part 2: Assessment and verification of constancy of performance
EN 14146:2004	Natural stone test methods - Determination of the dynamic modulus of elasticity (by measuring the fundamental resonance frequency

ANNEX A: TESTING THE SULFATE RESISTANCE – FLAT PRISM METHOD S_{FPM}

A.1 References

EN 196-1	Methods of testing cement - Part 1: Determination of strength
EN 197-1	Cement - Part 1: Composition, specifications and conformity criteria for common cements
EN 14146	Natural stone test methods - Determination of the dynamic modulus of elasticity (by measuring the fundamental resonance frequency)

A.2 General description of the test method

The sulfate resistance shall be determined by the flat prism method (S_{FPM}) on mortar specimens aged up to 26 weeks in a Na_2SO_4-solution (NS), and in a saturated calcium hydroxide ($CaOH_2$)-solution (CH) at a storage temperature (T) of (5 ± 2) °C (T_5) and (20 ± 2) °C (T_{20}).

The length and the mass as well as the longitudinal resonance frequency for the determination of the dynamic modulus of elasticity of the specimens are determined at regular intervals (0, 14, 28, 56, 91 and 182 days).

With the measured length of the specimens after a storage time t_i, the length difference of the flat prisms for each storage solution (NS and CH) and storage temperature (T_5 and T_{20}) shall be calculated as mean value from 3 specimens ($\Delta l_{NS,(ti,T)}$ and $\Delta l_{CH,(ti,T)}$).

The difference in elongation between the sulfate storage($\Delta l_{NS,(ti,T)}$) and the reference storage ($\Delta l_{CH,(ti,T)}$) for a storage time (t_i) and a storage temperature (T_5 and T_{20}) is given as expansion of the length ($\Delta l_{ti,T}$).

In addition, the mass of the specimens ($w_{NS,(ti,T)}$ and $w_{CH,(ti,T)}$) and the dynamic modulus of elasticity ($E_{d,NS,(ti,T)}$ and $E_{d,CH,(ti,T)}$) shall be determined at a storage time t_i for each storage solution (NS and CH) and storage temperature (T_5 and T_{20}).

Two further cements according to EN 197-1 (two different sulfate resisting common cements – SR-Cements) are included in the testing as reference cements. The results of the reference cements shall also be stated in the ETA.

A.3 Cements

The sulfate resistance shall be tested on specimens made of mortar according to EN 196-1 with "Blast Furnace Cement CEM III/A (SR/LH/LA)" and with at least two different SR-cements according to EN 197-1.

A.4 Making of test specimens

Mortar shall be made from each cement ("Blast Furnace Cement CEM III/A (SR/LH/LA)" and the two different reference cements) according to EN 196-1.

From each mortar 24 flat prisms with the dimensions 10 mm x 40 mm x 160 mm (12 with and 12 without measuring pin) shall be made according to EN 196-1 and be compacted on the vibrating table.

A.5 Storage of test specimens

The specimens are stored for (48 ± 2) hours in the mould, protected from drying at a temperature of (20 ± 2) °C and a relative air humidity of ≥ 95 %.

After demoulding, identify and indelibly mark each flat prism, including an arrow pointing towards the "top" of each prism for the purpose of using a consistent orientation for the measurements. Then examine the flat prisms and record any defects.

After demoulding the flat prisms shall be pre-stored until the age of 14 days, on edge, standing on gratings in saturated calcium hydroxide ($Ca(OH)_2$)-solution at (20 ± 2)°C.

After pre-storage:

For the sulfate storage (NS), 3 flat prisms with measuring pin and 3 flat prisms without measuring pin will be stored on edge, standing on gratings in the 4,4 % Na_2SO_4-solution at (5 ± 2) °C (= sulfate storage 5 °C = NS,T_5) and at (20 ± 2) °C (= sulfate storage 20 °C = NS,T_{20}).

For the reference storage (CH), 3 flat prisms with measuring pin and 3 flat prisms without measuring pin will be stored standing on edge, standing on gratings in a saturated $Ca(OH)_2$-solution at (5 ± 2) °C (= reference storage 5 °C = CH,T_5) and at (20 ± 2) °C (= reference storage 20 °C = CH,T_{20}).

In all storages the ratio of volumes of solution/solid matter must be 4:1.

During storage of the test specimens the containers must be air-tight sealed.

The Na_2SO_4 solution is to be replaced every 14 days with a new Na_2SO_4 solution, temperature-controlled at (5 ± 2) °C respectively (20 ± 2) °C.

The saturated $Ca(OH)_2$-solution is to be checked every 14 days for its saturation. If needed, it has to be concentrated.

A.6 Initial measurement procedure

After pre-storage, the test specimens are dried with a damp cloth after removal from the test solution at a room temperature of (20 ± 2) °C and a relative air humidity of 65 %.

Immediately afterwards the initial measurements shall be carried out to prevent the samples from drying out.

The flat prisms are weighed with a balance to an accuracy of 0,01 g (w_0).

The length of the flat prisms (with measuring pins) (l_0) will be measured on a dial gauge with an accuracy of 0,001 mm.

The dynamic modulus of elasticity of the flat prisms (without measuring pins) ($E_{d,0}$) will be calculated from measurements of the longitudinal resonance frequency ($F_{L,0}$) in accordance with EN 14146, clause 8.2.

Photographs of the flat prisms are taken to document their external appearance e. g. crack formation or spalling.

A.7 Further measurement procedure

After 14, 28, 56, 91 and 182[6] days of storage (t_i) in the respective test solutions (NS and CH) and storage temperature (T = 5 and 20), the test specimens are removed from the containers to determine the specimen length ($l_{NS,(ti,T)}$ and $l_{CH,(ti,T)}$), the mass ($w_{ti,T}$) and the longitudinal resonance frequency ($F_{L,NS(ti,T)}$ and $F_{L,CH(ti,T)}$) for the determination of the dynamic modulus of elasticity ($E_{d,NS(ti,T)}$ and $E_{d,CH(ti,T)}$).

For the tests, the test specimens are dried with a damp cloth after removal from the test solution at a room temperature of (20 ± 2) °C and a relative air humidity of 65 %.

Immediately afterwards the measurements shall be carried out to prevent the samples from drying out.

The flat prisms are weighed with a balance to an accuracy of 0,01 g ($w_{NS,(ti,T)}$ and $w_{CH,(ti,T)}$).

The length of the flat prisms (with measuring pins) ($l_{NS,(ti,T)}$ and $l_{CH,(ti,T)}$) will be measured on a dial gauge with an accuracy of 0,001 mm.

The longitudinal resonance frequency of the flat prims ($F_{L,NS(ti,T)}$ and $F_{L,CH(ti,T)}$) are determined following EN14146 to calculate the dynamic modulus of elasticity ($E_{d,NS(ti.T)}$ and $E_{d,CH(ti.T)}$).

In additions the external appearance of the flat prisms e. g. crack formation or spalling shall be documented with a description and photos.

[6] Only for the storage temperature of 20 °C the tests are continued for another 91 days.

A.8 Analysis

The length difference of the flat prisms (with measuring pins) is calculated as mean value from 3 specimens for each storage time (t), storage solution (NS or CH) and storage temperature (T = 5 and 20) ($\Delta l_{NS(ti,T)}$ and $\Delta l_{CH(ti,T)}$) by the following formula:

$\Delta l_{NS(ti,T)} = (l_{NS(ti,T)} - l_0) \times 100/160$ [mm/m]

$\Delta l_{CH(ti,T)}) = (l_{CH(ti,T)} - l_0) \times 100/160$ [mm/m]

with:

l_0 = length of the flat prisms after pre-storage (t = 0) [mm]

$l_{NS(ti,T)}$ = length of the flat prisms at storage time (t_i) [mm] in Na_2SO_4-solution at a storage temperature of 5 °C and 20 °C (T)

$l_{CH(t,T)}$ = length of the flat prisms at storage time (t_i) [mm] in $Ca(OH)_2$-solution at a storage temperature of 5 °C and 20 °C (T)

t_i = storage time 14, 28, 56, 91 and 182[6] days

The expansion of length ($\Delta l_{ti,T}$) between the sulfate storage($\Delta l_{NS(ti,T)}$) and the reference storage ($\Delta l_{CH(ti,T)}$) for each storage time are calculated by the following formula:

$\Delta l_{ti,T} = \Delta l_{NS(ti,T)} - \Delta l_{CH(ti,T)}$

ANNEX B: Determination of the glass content of granulated blast furnace slag

B.1 General

Granulated blast furnace slag is produced in blast furnace plants as moist granules with a grain size of 0 to 5 mm. The following test instructions have proved successfully for determination of the glass content by microscope.

B.2 Test equipment

The below-mentioned test equipment is necessary to carry out the test:

- porcelain mortar with pestle
- drying cabinet for 105 °C, or vacuum cabinet
- air-jet screening machine
- air-jet screen with 0,04 mm mesh
- hand sieve with 0,06 mm mesh
- hot plate with temperature control
- Canada balsam
- microscope slide and cover glass
- polarizing microscope for transmitted light (up to 250 x magnification), if possible with whole-wave plate (e.g., quartz red I) as auxiliary objective lens.

B.3 Sample preparation

The sample of granulated blast furnace slag of approximately 500 g is dried in a drying cabinet at 105 °C or in a vacuum cabinet at room temperature.

The dried sample is then split to give a sub-sample of approximately 25 g. This sub-sample is completely comminuted by careful grinding until no residue remains on the 0-0,06 mm mesh hand sieve. Thereafter the fraction smaller than 0,04 mm is screened off with air-jet screen. In order to obtain a homogeneous dispersed preparation which is free from fines and oversize material the 0,04 mm to 0,06 mm particle size fraction is again screened on the 0,06 mm hand sieve mesh and air-jet screen with 0,04 mm mesh. The particle size fraction 0,06 to 0,04 mm is sufficiently fine for investigation under a microscope.

A microscope slide is placed on a hot plate heated to approximately 130 °C and enough Canada balsam is melted on it to cover about the third of the slide with melted Canada balsam. The heating is continued until no more little bubbles can be seen. A small quantity of the screened grains of granulated blast furnace slag is scattered on the softened Canada balsam with spatula and the dispersed granulated preparation is covered with a cover glass. A thin uniform layer of Canada balsam and screened granulated blast furnace slag is generated by light pressure and movement of the cover glass. After cooling, the grains of granulated blast furnace slag shall be distributed evenly in the Canada balsam without forming lumps. Excess Canada balsam is removed with xylene. The finished dispersed preparation is investigated with a microscope using polarized transmitted light at 200 to 250 x magnification.

B.4 Test execution

With crossed polarizers the glassy particles remain dark. Cubically crystallized components also remain dark, but such components are extremely rare in granulated blast furnace slag and can therefore be ignored when determining the glass content. The other crystalline components appear light. When the microscope stage is rotated through 90° these crystalline components appear alternately light and dark.

The use of whole-wave plate (e.g., quartz red I) with crossed polarizers makes it easier to differentiate between crystalline and non-crystalline components. In this case the glassy components have the same uniform colour as the background all the time and can only be detected by their contours. Crystalline nonglossy components stand out by having a different colour from the background.

B.5 Determination of the glass content

To determine the glass content, it is necessary to count at least 1000 grains and classify them into the following groups:

A: purely glassy grains

B: glassy grains (approx. 90 % glass) with small crystalline content

C: glassy grains (approx. 40 % glass) with increased crystalline content

D: grains with no glassy components (approx. 0 % glass)

E: foreign components, e.g., opaque particles

The glass content G in percent is calculated by following formula:

$$G\ [\%] = \frac{(A + 0{,}9 \cdot B + 0{,}4 \cdot C)}{(A + B + C + D)}$$

The fraction of foreign constituents E is not taken into account when calculating the glass content.