

# Regulations for Certification and Testing of Cement for P-marking

## **Abstract**

### **Certification of cement**

After permission from the Swedish National Testing and Research Institute (SP), manufacturers may use the P-symbol to mark their products. Before a marking permit is given it must be verified that the products fulfil the requirements contained in a standard, or equivalent, recognised by SP. An agreement must also be made concerning continuous quality control of the products.

This report contains the requirements for certification (P-marking) of cement for building purposes.

The emphasis is on functional and safety requirements such as strength and chemical composition.

The continuous quality control is made mainly by the manufacturer. The manufacturer's control is checked through inspections made by SP. These inspections are carried out in the plant and at locations for import. The main purpose with the quality control is to see that the requirements on the cement are fulfilled.

Key words: certification, cement, P-marking, requirements, quality control,

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## **Preface**

Certification of cement (P-marking) is a system for certification of conformity that has been developed by SP in consultation with representatives of Swedish cement manufacturers.

As far as possible, it has been SP's objective to harmonise inspection and testing with the requirements of the Construction Products Directive for testing and certification (Guidance papers 7, 9 and 10). The programme has been designed as a flexible system in order to facilitate harmonisation with / changing to future EC standards and EC modules. The product requirements described here have been developed on the basis of the requirements set out in ENV 197-1 and in relation to current standardisation work within CEN/TC 51.

In addition, it is possible to certify cement in respect of its sulphate resistance and alkalinity characteristics, based on requirements set out in the National Road Administration's BRONORM 88, 4 Concrete Superstructures (Publication 1988:204) and the Swedish Concrete Association's Concrete Report no.1, Durable Concrete Structures.

Certification of Pozzolan cement and of blended cement (CEM IV and CEM V in ENV 197-1), and of Portland blended cement containing silica fume, pozzolan, shale, limestone or a mixture thereof, are not included in these certification regulations.

The main responsibility for inspection and testing is with the manufacturer, and the main emphasis is on performance requirements. The primary objective is to ensure that product requirements are fulfilled.

Borås, 1993

Matz Sandström

## 1. Introduction

Certification involves confirmation by an independent third party that a product conforms with a specified standard or other specification. At SP, certification is carried out by a body that is separate from other testing and inspection work. The certification body is subordinate to a special certification board, which includes representatives from the commercial sectors concerned. The certification board can appoint expert groups for various product sectors, including groups intending to act as technical committees. Certification of products by SP is performed in accordance with EN 45011.

The P-symbol is SP's certification symbol, i.e. the symbol for SP's own certification system. Products which, after testing and other checks, show that they meet specified requirements, and which are further monitored on an ongoing basis by continuous manufacturing testing and inspection, can be granted permission by SP to use the P-symbol.

'P-marking of cement' is SP's system for certifying cement intended for use in buildings.

The system comprises not only inspection and testing of cement manufacture, but also inspection and testing of the finished product. In this context, 'product' refers to cement. The cements covered by this certification scheme are listed in Table 1.

**Table 1: Cement classifications**

Classification in accordance with ENV 197-1	Classification in acc. with B1 1960 Utgåva 2, 1982
CEM I Portland cement	P
CEM II/A-S Portland-slag cement	M
CEM II/B-S Portland-slag cement	M
CEM II/A-V Portland-fly ash cement	M
CEM II/B-V Portland-fly ash cement	M
CEM III/A Slag cement	B
CEM III/B Slag cement	B

Equivalence between the types of cement in accordance with ENV 197-1 and B1 1960 is only approximate, as - apart from Portland cement clinker - the definitions of the various constituents are not the same.

In order to be granted permission to use the P-symbol, a manufacturer must document that the product fulfils the requirements set out in Appendix 1. In addition, continuous quality of the manufactured product must be assured by means of in-house testing and inspection (auto control) performed by the manufacturer in accordance with Section 4.2 of these regulations and by the manufacturer's quality system. This inspection and testing is, in turn, monitored by SP.

If testing/inspection, manufacturer's inspection or supervisory inspection monitoring show that the products no longer fulfil the requirements, they may not continue to display the P-symbol until the cause of the non-compliance has been identified and rectified. Procedures and application of manufacturer's testing/inspection are defined in these certification rules (SP RAPPORT 1992:56E), and confirmed in a contract between the manufacturer and SP.

## **2. Conditions for certification**

### **2.1 Extent**

The manufacture of cement must be checked in accordance with the certification rules. Manufacturing inspection comprises not only the manufacturer's factory production control, i.e. regular in-house testing and inspection under skilled direction and supervision (Sections 3 and 4.2), but also sample-based supervisory testing/inspection by SP (Section 4.3).

The following conditions must be fulfilled before certification can be performed:

- a) The manufacturer must have a documented quality system in accordance with Section 3 of these rules.
- b) Initial inspection has been performed by SP: see Section 2.2.
- c) Type-testing of the product has been performed by SP in order to determine whether requirements in respect of characteristics as set out in Section 2.3 are fulfilled.
- d) The company shall have prepared a relevant product description.
- e) A contract regulating on-line manufacturing testing and inspection has been entered into between the company and SP: see Appendix 3.

Applications for P-marking of products from a given factory, together with appropriate documentation in accordance with a) - d) above, shall be sent to SP.

Companies receiving certificates are noted in SP's list of certified products. Permission to apply P-marking is confirmed by SP through the issue of a certificate for each factory. The contract represents permission for the factory to mark shipping notes, delivery notes etc. and packages for the certified product with SP's P-symbol (Appendix 2).

Other terms and conditions are set out in Section 6.

### **2.2 Initial inspection**

Before an agreement concerning manufacturing testing and inspection can be entered into, premises, test equipment and manufacturing processes must be inspected, and test results from the manufacturer's own testing and inspection procedures must be assessed by SP. In addition, the manufacturer's quality system must be viewed in respect of compliance with requirements as set out in Section 3.

## 2.3 Type-testing

Type-testing is performed by SP in respect of the characteristics set out in Table 2. The types of cement covered by the certification regulations are listed in Table 1.

The test methods shown are reference methods. Other methods may be used, provided that their results accord with those of the reference methods. This can be demonstrated by comparison testing against the reference method or by using reference materials.

Products of which the characteristics are well documented, e.g. as a result of manufacturing inspection by SP, and which are regarded as fulfilling the requirements for certification in accordance with Appendix 1, can be certified without type-testing if other terms and conditions are fulfilled.

**Table 2: Type-testing and assessment of cement.**

Characteristic	Test method	Cement type	requirement
Compressive strength	EN 196-1 (SS 13 42 33)	All	Appendix 1.3 <sup>1)</sup>
Setting time	EN 196-3 (SS 13 42 31)	All	Appendix 1.3 <sup>1)</sup>
Soundness	EN 196-3 (SS 13 42 31)	All	Appendix 1.3 <sup>1)</sup>
Loss of ignition	EN 196-2 (SP-method 659)	CEM I, III,	Appendix 1.4 <sup>1)</sup>
Insoluble residues	EN 196-2 (SP-method 660)	CEM I, III,	Appendix 1.4 <sup>1)</sup>
Sulphate content (as SO <sub>3</sub> )	EN 196-2 (SP-method 658)	All	Appendix 1.4 <sup>1)</sup>
Chloride content	EN 196-21 (SP-method 665)	All	Appendix 1.4 <sup>1)</sup>
Alkali content	EN 196-21 (SP-method 656)	Low-alkali cement (LA)	Appendix 1.5 <sup>2,3)</sup>
C <sub>3</sub> A-content	EN 196-2 (SP-methods 655, 657 and 658), with calculation in acc. with ASTM C 150	Sulphate-resistant cement (SR)	Appendix 1.5 <sup>2,3)</sup>

1) ENV 197-1

2) The Swedish National Road Administration's BRONORM 88

3) The Swedish Concrete Association's Concrete report 1, Durable Concrete Structures.



### **3. Quality assurance and quality control**

The manufacturer must have a documented system for quality assurance, setting out all planned and systematic measures necessary to ensure adequate confidence that a certified (P-marked) product will fulfil relevant quality requirements. The system shall indicate a person in the company who is responsible for quality assurance. This person shall be authorised and required to ensure that the intended quality of the products is fulfilled and maintained.

The manufacturer's quality system shall be suited to the requirements of production and process control, and shall include suitable descriptions of the operative methods and activities employed in order to fulfil quality requirements. The quality system shall consist of at least the following:

- Quality policy, organisation, responsibility and authority in respect of product quality;
- Routines for handling and testing/inspecting raw materials and intermediate products;
- Routines for manufacturing, process and production control;
- Routines for tests and inspection of raw materials, intermediate products and finished products, together with details of the frequency of which they are to be performed (auto control);
- Routines for handling, storage and transport of the finished product;
- Corrective actions in response to departure from product requirements.

The person responsible for quality in the company shall be available during SP's visits, and shall provide all necessary information and documentation. The manufacturer shall grant SP's personnel unrestricted access to manufacturing premises and stores.

Manufacture and continuous quality control shall be carried out by personnel having the necessary skills and training. Working duties, authority, skills and training of this personnel shall be documented.

The manufacturer shall perform comprehensive and planned internal quality audits, intended to verify that the quality system accords with the standard employed, and that quality work is complying with the company's own documentation. The results of the quality audits shall be documented and made known to personnel concerned.

## **4. Inspection rules**

### **4.1 Extent**

Inspection and testing shall be performed on the product as ready for delivery. References to different cements (products) refer to different types of cement, in accordance with ENV 197 - 1, Table 1 /1/, BRONORM 88, Chapter 4, Concrete Superstructures /25/, the Swedish Concrete Association, Durable Concrete Structures, Concrete Report no. 1 /24/, and which differ from each other or products that are produced in different manufacturing plants. Inspection/testing shall be performed partly by the manufacturer's regular and ongoing in-house inspection in accordance with Section 4.2, and partly by supervisory monitoring inspection, performed by SP in accordance with Section 4.3.

### **4.2 Manufacturer's inspection**

#### **4.2.1 General**

Manufacture and ongoing testing/inspection shall be carried out in accordance with documented routines, as described in Section 3. The objective of such testing/inspection is to verify that the intended quality is being obtained and maintained, and involves testing in the factory's laboratory, or in some other laboratory, the services of which are employed by the manufacturer for the manufacturer's own inspection under regulated forms.

Each manufacturer shall apply ongoing testing/inspection of at least the extent described in Section 4.2.2. The results shall be evaluated as described in Section 5.1. Testing/inspection shall be logged in accordance with the manufacturer's quality system. The company's representative shall notify SP, at least twice a year, of details of test/inspection results from the manufacturer's own inspection. In addition, the company's representative shall immediately notify SP if test results do not fulfil the requirements set out in Section 5.1.

## 4.2.2 Sampling for manufacturer's inspection

EN 196 - 7 requires sampling to be performed at the place of manufacture, e.g. at the point of outward delivery from the factory, and in accordance with a formal sampling plan as set out in Section 5.1.1. The samples shall be taken over a period of not less than six, and not more than twelve, months. Tables 3 and 4 indicate the minimum frequencies.

**Table 3: Minimum sampling frequency in accordance with ENV 197 - 1**

Property	Number of samples
Compressive strength Sulphate content Setting time Soundness	2 per week at the time of production/delivery
Chloride content Loss by combustion Insoluble residue	1 per month at the time of production/delivery
Chemical analysis of relevant substances	1 test per year

**Table 4: Minimum sampling frequency for other characteristics**

Property	Number of samples
Alkali content C <sub>3</sub> A-content	1 per month at the time of production/delivery

## 4.3 Supervisory (monitoring) inspection

### 4.3.1 Extent

The supervisory (monitoring) inspection is performed by SP, and consists of the following elements:

- Inspection (see 4.3.2 [below])
- Random sampling inspection (see 4.3.3)
- Assessment of test results from the manufacturer's own inspection (see 4.3.4).

### 4.3.2 Inspection

Inspection will be carried out by means of at least one visit per year to each factory, at times determined by SP. The manufacturer shall be notified in advance of an impending inspection visit.

Inspection involves checking:

- that the quality system accords with requirements as set out in Section 3, and that quality work is being carried out in accordance with the manufacturer's own documentation; <sup>1)</sup>
- that the manufacturer is performing in-house testing/inspection to the necessary extent;
- that the test/inspection results fulfil requirements as set out in Section 5.1; <sup>2)</sup>
- that SP has been notified if test/inspection results have not fulfilled the requirements of Section 5.1;
- that the operating instructions are being followed when in-house test/inspection results differ from specified requirements and from any set values;
- that instruments and test/inspection equipment used by the company in its own testing/inspection work are themselves inspected/calibrated; <sup>3)</sup>
- that laboratory personnel possess the necessary knowledge of testing and working methods. <sup>3)</sup>

- 1) This extent may be reduced if the manufacturer's quality system is certified by an accredited certification body.
- 2) In addition, the fact that the test/inspection results from the manufacturer's own testing/inspection fulfils the requirements of Section 5 shall be checked by correspondence; see Section 4.3.4.
- 3) This can be reduced if a quality system to EN 45001, certified by an accredited certification body, is being used.

Any observations made during inspections shall be noted and countersigned by the manufacturer's representative. Not later than two weeks after inspection, SP will send a report to the manufacturer's quality representative. This report will contain details of significant observations and notes made during the inspection. Not later than eight weeks after the inspection, SP will send a test report to the manufacturer's quality representative, containing details of all tests and inspections that have been performed and of the results thereof.

### **4.3.3 Random sampling inspection**

Sampling inspection is intended to check that the product fulfils requirements in respect of the following characteristics:

1. Compressive strength (at two ages)
2. Setting time
3. Soundness
4. Characteristics in accordance with Appendix 1.5 for which the cement is certified
5. Other characteristics (checked once a year).

SP will arrange the taking of one random sample per month for each product and each manufacturing plant/store. One of these random samples will be taken in connection with approval inspection. The samples will be taken from products ready for delivery, as specified in EN 196 - 7. They will be homogenised and divided into two parts, one of which will be retained by SP, while the other will be sent to the laboratory that the manufacturer may use for his in-house inspection.

Not later than six weeks after sampling, the manufacturer's person responsible for inspection/testing shall notify SP in writing of the test results from the random sample taken by SP. SP will evaluate the results in accordance with Section 5.2 and prepare a report on the results of the random inspection, comparing the manufacturer's production statistics with the statistics produced by SP on the basis of the results from random sampling inspection/testing. This report will be sent to the manufacturer not later than eight weeks after taking the samples.

### **4.3.4 Monitoring of test results from the manufacturer's inspection**

Twice a year, checks shall be run to ensure that the results from the manufacturer's own inspection accord with the requirements in the certification rules, as set out in Section 5.1. This will be done in connection with approval inspection (see Section 4.3.2) and via correspondence.

### **4.3.5 Reporting**

SP will submit an annual report to the manufacturer on inspection/test activities. A copy will be sent to SP's certification unit.

#### **4.4 Actions in response to shortcomings and non-conformance**

Products exhibiting a greater proportion of faults than as specified in Sections 5.1.2 and 5.1.3 do not fulfil the requirements for certification. Routines for corrective actions in the event of non-conformance with the requirements shall be described in the manufacturer's quality system. Details shall be noted when such corrective actions are taken. The manufacturer is required to perform all such investigations and/or testing and inspection over and above the regular testing and inspection work as may be necessitated by observed shortcomings and non-conformance. The effects of corrective actions shall be monitored.

Procedures for separation of sub-standard products shall be described in the manufacturer's quality system. These procedures may include admixture in other grades of cement under controlled forms. Batches that, in one or more respects, suffer from a significant fault (see Section 5.1.4) may not be sold as P-marked cement. Customers who have received deliveries from such a batch shall be immediately notified of the circumstances, and suitable measures shall be taken in respect of what has occurred.

In the event of serious shortcomings and/or non-conformances, or of repeated observations thereon that have clearly not resulted in correction, the right of the manufacturer to use the P-symbol may be withdrawn.

#### **4.5 Changed manufacturing conditions**

Prior to significant changes that can affect the characteristics of the product, the manufacturer shall notify SP thereof. SP shall then decide if, and to what extent, renewed or further type-testing is required.

## 5. Assessment of conformity with requirements

### 5.1 Evaluation of manufacturer's own inspection

#### 5.1.1 General procedures for assessing conformity

Evaluation of conformity with product requirements will be performed in accordance with the principles set out with ENV 197 - 1. A summary is given below of how this assessment is to be performed: the procedure is described in detail in ENV 197 - 1, Section 9 and Annex A. Assessment shall be based on material ready for delivery. The samples shall be taken over a period (inspection period) of not less than six, and not more than twelve, months at a frequency as set out in Section 4.2.2. The sampling plan shall be drawn up in accordance with the requirements shown in Table 5.

**Table 5: Parameters determining the conformity procedure.**

	Compressive strength		Physical and chemical properties
	2 (7) and 28 days Lower limit	28 days Upper limit	
Continuous inspection procedure	Variable inspection	Variable inspection	Variable inspection or attribute testing
Max. permissible proportion of defects	5 %	10 %	10 %
Consumers risk	5 %	5 %	5 %

An observed test result that differs in one or more respects from the product requirements as set out in Appendix 1 shall be noted as a fault. Faults can be classified as less serious or as significant faults (see Section 5.1.4).

#### 5.1.2 Monitoring of variables

Assessment of compliance will be based on the results of assessment of each characteristic on its own. Assessment involves calculation of the mean value ( $\bar{x}$ ) and the standard deviation ( $s$ ) of all samples (based on one result per sample) taken during the monitoring period as defined in Section 5.1.1. The criterion for approval is that each characteristic shall be greater or less than

$$\bar{x} - k_A s \geq L$$

or

$$\bar{x} + k_A s \leq U$$

where L is the lower requirement limit and U is the upper requirement limit as specified in Appendix 1. The acceptance constant,  $k_A$ , depends on the number of samples, as set out in Table 6.

### 5.1.3 Evaluation by attributes

Assessment of compliance is based on assessment of each characteristic on its own. In this case, the number of failed results ( $C_D$ ), based on one result per sample, is calculated for the inspection period. A failed result is defined as one having a value that is less than or which exceeds the requirements as set out in Appendix 1. The criterion for approval will be assessed in accordance with the equation below, in which the number of permissible defects,  $C_A$ , depends on the number of samples as set out in Table 7.

$$C_D \leq C_A$$

**Table 6: Acceptance constant  $k_A$**

Variable inspection		
No. of samples	$p_a = 5\%$	$p_a = 10\%$
40 to 49	2.13	1.70
50 to 59	2.07	1.65
60 to 79	2.02	1.61
80 to 99	1.97	1.56
100 to 149	1.93	1.53
150 to 199	1.87	1.48
$\geq 200$	1.84	1.45

**Table 7: Acceptable number of failed results**

Attribute inspection	
No. of samples	$C_A$
20 to 39	0
40 to 54	1
55 to 69	2
70 to 84	3
85 to 99	4
100 to 109	5

### 5.1.4 Significant deviations from specification

Significant deviations from specification are regarded as those deviations from the product requirements set out in Appendix 1 which significantly reduce the utility of the product for its intended purpose. Significant deviations are defined as in those greater than as set out in Tables 8 and 9. A batch which suffers from one or more such deviations does not comply with the requirements of these inspection regulations, or with ENV 197 - 1, and must not be sold as P-marked cement.

**Table 8: Major defects according to EN 197-1**

Property	Deviations regarded as major defects
Compressive strength: lower limit	- 2.5 N/mm <sup>2</sup> (28 days) - 2.0 N/mm <sup>2</sup> (2 (7) days)
Setting time	- 15 min (Strength class 32.5 and 42.5) - 5 min (Strength class 52.5)
Soundness	+ 1 mm
Chloride content	+ 0.01 %
Sulphate content	+ 0.5 %



**Table 9: Significant deviations from specification for low-alkali cement and for sulphate-resistant cement.**

Property	Deviations regarded as major defects
Equivalent Na <sub>2</sub> O content	+ 0.2 %
C <sub>3</sub> A content	+ 2 %

## 5.2 Assessment of sampling inspection results

### 5.2.1 General

Evaluation of the results of sampling inspection involves statistical evaluation of agreement between the manufacturer's own inspection and the manufacturer's and SP's testing of the random samples. The model is intended for evaluation of characteristics checked by means of variable inspection. Inspection is divided up into three parts as follows:

1. Comparison between the manufacturer's results from manufacturer's inspection and from random sampling inspection.
2. Comparison between the manufacturer's results and SP's results from random sampling inspection.
3. Checking for the occurrence of non-conformance with product requirements as set out in Appendix 1.

### 5.2.2 Comparison of results from the manufacturer's inspection and from random sampling inspection

This comparison aims to evaluate the variation (homogeneity) of the manufacturer's own inspection and the representativity of the sample tests. If the number of manufacturer's own inspections is at least 50, the calculations shall be performed as set out in ISO 2854, Table A, (Comparison between mean value and a given value when the variance is known). This enables calculation of a comparison factor,  $u$ , as given by

$$u = \frac{|\bar{x}_s - \bar{x}_e|}{s_e / \sqrt{n_s}}$$

where:

$\bar{x}_s$  is the mean value of the random samples

$\bar{x}_e$  is the mean value of samples from the manufacturer's own inspection

$s_e$  is the standard deviation of samples from the manufacturer's own inspection

$n_s$  is the number of random samples

If the number of inspections in the manufacturer's own inspection is less than 50,  $u$  shall be calculated from:

$$u = \frac{|\bar{x}_s - \bar{x}_e|}{s_d}$$

$$S_d \text{ is calculated from } s_d = \sqrt{\frac{(n_s + n_e)}{n_s n_e} \cdot \frac{(n_s - 1)s_s^2 + (n_e - 1)s_e^2}{(n_s + n_e - 2)}}$$

where:

$s_s$  is the standard deviation of the random samples

$n_e$  is the number of samples in the manufacturer's own inspection.

If  $u > 2.58$ , the reason for the non-conformance shall be investigated. One reason for non-conformance may be that the various samples have been taken at different places.

### 5.2.3 Comparison of results from the manufacturer's inspection and SP's random sampling inspection

This evaluation investigates whether there is any significant difference between the results from SP's testing of the random samples and the results from the manufacturer's testing thereof. It is performed as a comparison of pairs of sample tests in accordance with the procedures as set out in ISO 3301. This involves calculation of the differences between the manufacturer's results,  $x_{\text{manufacturer}}$ , and SP's results,  $x_{\text{SP}}$ , for each sample test,  $d_i$ , as given by:

$$d_i = x_{\text{SP}} - x_{\text{manufacturer}}$$

This is followed by calculation of the mean value of the differences,  $\bar{d}$ , the standard deviation,  $s_s$  and the confidence interval for the mean value,  $I$ , at the 5% level, from:

$$\bar{d} = \frac{1}{n_s} \sum d_i$$

$$s_s = \sqrt{\frac{1}{(n_s - 1)} \cdot \sum (d_i - \bar{d})^2}$$

$$I = s_s \cdot K$$

where  $K$  is a constant that depends on the number of sample tests, as shown in Table 10.

If  $|\bar{d}| > I$ , the difference between SP's results and those of the manufacturer is significant, and the reasons therefor shall be investigated.

**Table 10: Values of constant K for a confidence level of 0.05**

No. of samples	$n_s-1$	K	No. of samples	$n_s-1$	K	No. of samples	$n_s-1$	K
2	1	8,895	10	9	0,715	18	17	0,497
3	2	2,434	11	10	0,672	19	18	0,482
4	3	1,591	12	11	0,635	20	19	0,468
5	4	1,242	13	12	0,604	30	29	0,373
6	5	1,049	14	13	0,577	40	39	0,324
7	6	0,925	15	14	0,554	60	59	0,258
8	7	0,836	16	15	0,533	120	119	0,182
9	8	0,769	17	16	0,514	$\infty$	$\infty$	0

#### **5.2.4 Inspection of non-conformances with the product specification**

The results from the manufacturer's and SP's tests of the random samples shall be investigated in respect of non-conformances with the product requirements after application of any corrections that may be required by the results of the evaluations in Sections 5.2.2 or 5.2.3. If any defect(s) is/are detected thereafter, corrective actions as described in Section 4.4 shall be taken.

## **6. Withdrawal of certificate**

The general regulations applicable to certification are set out in 'General Regulations for Certification'. The following material complements the General Conditions in respect of the routines associated with withdrawal of certificates in connection with certification of cement.

In the event of serious irregularities, SP can recall a certificate with immediate effect. Normally, however, the manufacturer is given an opportunity to rectify the non-conformances that have been noted. In such cases, SP sends a written notification to the manufacturer, setting out a period of time within which the non-conformances must be rectified.

At the end of this period of time, an additional inspection will be carried out. If serious non-conformances then remain, permission to use the P-symbol will be formally revoked on the same day as the visit. If permission to use the P-symbol is revoked, the manufacturer is required, against a penalty of SEK 200 000:-, immediately to cease citing SP's P-symbol or using it to mark its products.

Decisions to withdraw the right to use the P-symbol will be taken by the person responsible for SP's certification activities, in the light of the points stated in this report (SP RAPPORT 1992:56). Appeals shall be in writing, and will be processed by SP's certification board.

Certification will be withdrawn from companies that have not produced any certified cement for a period of one year.

The same rules apply for reinstatement of certification as apply in connection with initial issue thereof. However, further type-testing will not be required if a period of less than one year has passed since permission to use the symbol was withdrawn, unless the rules for certification or production conditions have been changed.

## **7. Fees**

Costs for the supervisory (monitoring) inspection are payable by the manufacturer. Billing will be made on quarterly basis and in accordance with SP's standard rates. An annual fee is charged for membership of the certification system: SP debits a charge for certification in accordance with its current tariff.

## **8. Changes to these regulations**

SP reserves the right to modify these regulations. Proposals for modification shall have been discussed by the certification board before being applied. A example of a reason for modification could be that the standards, regulations etc. to which reference is made in this document, have been revised.

Modification of the regulations may also be necessary as a result of experience or of the development of new materials or products.

Revisions of these certification rules will be issued in the form of a memorandum, and confirmed in SP's Certification Rules.

Extension of permission to use the P-symbol, issued under earlier rules, requires the manufacturer to undertake to comply with the revised rules. However, the manufacturer shall be allowed a reasonable time for making any changes necessary to comply with the revised requirements.

## 9. References

1. ENV 197-1: 1992, Cement - Composition, specification and conformity criteria - Part 1: Common cement.
2. EN 196-1:1987, Methods of testing cement - Determination of strength.
3. EN 196-2:1987, Methods of testing cement - Chemical analysis of cement.
4. EN 196-3:1987, Methods of testing cement - Determination of setting time and soundness.
5. ENV 196-4:1989, Methods of testing cement - Quantitative determination of constituents.
6. EN 196-6:1987, Methods of testing cement - Determination of fineness.
7. EN 196-7:1989, Methods of testing cement - Methods of taking and preparing samples of cement.
8. EN 196-21:1989, Methods of testing cement - Determination of the chloride, carbon dioxide and alkali content of cement.
9. EN 29002, Quality systems - Model for quality assurance in production and installation.
10. EN 45001, General criteria for the operation of testing laboratories.
11. European Commission's Standing committee for Construction, Guidance Paper N° 7, Guidelines for the performance of the factory production control for construction products.
12. European Commission's Standing Committee for Construction, Guidance Paper N° 9, Guidelines for the certification of construction products by an approved body.
13. European Commission's Standing committee for Construction, Guidance Paper N° 10, Guidelines for the assessment and certification of the factory production control by an approved body.
14. ISO 2854-1976, Statistical interpretation of data - Techniques of estimation and tests relating to means and variances.
15. ISO 3301-1975, Statistical interpretation of data - Comparison of two means in the case of paired observations.
16. Statens Betongkommitté: Statliga Cementbestämmelser, B1 1960, Utgåva 2 (1982), AB Svensk Byggtjänst, Stockholm.
17. Swedish National Testing and Research Institute: SP- method SP 655, Cement - Bestämning av kisel, aluminium, järn, magnesium, titan, mangan, kalcium, natrium och kalium.
18. Swedish National Testing and Research Institute: SP- method SP 656, Cement, oxidiska material mm. - Bestämning av totalt natrium och kalium.
19. Swedish National Testing and Research Institute: SP- method SP 657, Cement, oxidiska material mm. - Bestämning av kalcium.
20. Swedish National Testing and Research Institute: SP- method SP 658, Cement, oxidiska material mm. - Bestämning av svavel.
21. Swedish National Testing and Research Institute: SP- method SP 659, Cement, oxidiska material mm. - Bestämning av fukthalt och glödförlust.
22. Swedish National Testing and Research Institute: SP- method SP 660, Cement, oxidiska material mm. - Bestämning av olöslig rest.
24. Swedish National Testing and Research Institute: SP- method SP 665, Cement, oxidiska material mm. - Bestämning av klorid.

25. Svenska Betongföreningen: Beständiga betongkonstruktioner, Betongrapport nr 1, Stockholm 1991.
26. Vägverket, BRONORM 88, 4. Betongöverbyggnad, Publ 1988:204.
27. Vägverket, BROBREV nr 6, Publ 1993:1.



# **Test method and requirements for cement to be P-marked**

## **1. General**

The requirements for P-marking of cement are based on those in ENV 197 - 1, Cement - Composition, specification and conformity criteria - Part 1: Common cement. These requirements are set out in Section 2. Additional requirements applicable to cements having special characteristics are set out in Sections 3 - 6. In these cases, allowance has been made for the requirements in the National Road Administration's BRONORM 88, 4, and in the Swedish Concrete Association's Report no.1, Durable Concrete Structures.

Requirements relating to chromate reduction and to cement with limited heat generation are in process of operation, which means that such cements cannot be certified until the results from this work are available.

The methods of testing described below are reference methods. Other methods may be used provided that the results therefor agree with those of the reference methods. Such agreement can be demonstrated by means of comparison testing against the reference method or by using reference materials.

## **2. Requirements on cement in accordance with ENV 197 - 1**

### **2.1 General**

ENV 197 - 1 divides cement up into five main types, depending on their composition:

- I. Portland cement
- II. Portland - composite cement
- III. Blastfurnace cement
- IV. Pozzolan cement
- V. Composite cement

Detailed descriptions of, and requirements applicable to, the various constituents of cement are set out in ENV 197 - 1, Section 4. Table 1 indicates the composition of the various types of cement covered by ENV 197 - 1, together with their designations.

Table 1: Composition by mass, % 1) of various types of cement in accordance with ENV 197-1.

Cement type	Designation	Notation	Clinker K	Granulated blastfurnace slag S	Silica fume D <sup>3)</sup>	Pozzolana		Flyg ashes		Burnt shale I	Lime-stone L	Minor additional constituents <sup>2)</sup>	
						Natural P	Industrial Q <sup>4)</sup>	Siliceous V	Calcareous W				
I	Portland cement	I	95 - 100	—	—	—	—	—	—	—	—	0 - 5	
	Portland slag cement	II/A-S	80 - 94	6 - 20	—	—	—	—	—	—	—	0 - 5	
		II/B-S	65 - 79	21 - 35	—	—	—	—	—	—	—	0 - 5	
		II/A-D	90 - 94	—	6 - 10	—	—	—	—	—	—	0 - 5	
II	Portland pozzolana cement	II/A-P	80 - 94	—	—	6 - 20	—	—	—	—	—	0 - 5	
		II/B-P	65 - 79	—	—	21 - 35	—	—	—	—	—	0 - 5	
		II/A-Q	80 - 94	—	—	—	6 - 20	—	—	—	—	0 - 5	
		II/B-Q	65 - 79	—	—	—	21 - 35	—	—	—	—	0 - 5	
	Portland fly ash cement	II/A-V	80 - 94	—	—	—	—	6 - 20	—	—	—	—	0 - 5
		II/B-V	65 - 79	—	—	—	—	21 - 35	—	—	—	—	0 - 5
		II/A-W	80 - 94	—	—	—	—	—	6 - 20	—	—	—	0 - 5
		II/B-W	65 - 79	—	—	—	—	—	21 - 35	—	—	—	0 - 5
Portland burnt shale cement	II/A-I	80 - 94	—	—	—	—	—	—	—	6 - 20	—	0 - 5	
	II/B-I	65 - 79	—	—	—	—	—	—	21 - 35	—	—	0 - 5	
	II/A-L	80 - 94	—	—	—	—	—	—	—	6 - 20	—	0 - 5	
	II/B-L	65 - 79	—	—	—	—	—	—	—	21 - 35	—	0 - 5	
Portland composite cement	II/A-M	80 - 94	—	—	—	—	—	—	—	—	—	0 - 5	
	II/B-M	65 - 79	—	—	—	—	—	—	—	—	—	0 - 5	
III	Blast furnace cement	III/A	35 - 64	35 - 65	—	—	—	—	—	—	—	0 - 5	
		III/B	20 - 34	66 - 80	—	—	—	—	—	—	—	0 - 5	
		III/C	5 - 19	81 - 95	—	—	—	—	—	—	—	0 - 5	
IV	Pozzolanic cement	IV/A	65 - 89	—	<-----	11 - 35	—	—	—	—	—	0 - 5	
		IV/B	45 - 64	—	<-----	36 - 55	—	—	—	—	—	0 - 5	
V	Composite cement	V/A	40 - 64	18 - 30	—	<-----	18 - 30	—	—	—	—	0 - 5	
		V/B	20 - 39	31 - 50	—	<-----	31 - 50	—	—	—	—	0 - 5	

- 1) The values in the table refer to the cement nucleus, excluding calcium sulphate and additives.
- 2) Minor additional constituents may be filler or may be one or more of the main constituents if unless these are included as a main constituent in the cement.
- 3) The proportion of silica fume is limited to 10%.
- 4) The proportion of non-ferrous slag may be limited to 15%.
- 5) The proportion of filler is limited to 5%.

## 2.2 Mechanical and physical properties

### 2.2.1 Compressive strength

The compressive strength shall be determined at 28 days in accordance with EN 196 - 1 (standard strength). ENV 197 - 1 specifies three classes of cement in respect of standard strength; Class 32.5, Class 42.5 and Class 52.5 (see Table 2). Each of these classes contains two further classes based on early strength after two days or seven days. In the case of P-marked products, the requirements as shown in Table 2 shall be fulfilled.

**Table 2: Mechanical and physical properties**

Class	Compressive strength (MPa)			Setting time (min)	Soundness (mm)
	Early strength		Standard strength		
	2 days	7 days	28 days		
32,5	—	≥ 16	≥ 32,5 and ≤ 52,5	≥ 60	≤ 10
32,5 R	≥ 10	—			
42,5	≥ 10	—	≥ 42,5 and ≤ 62,5		
42,5 R	≥ 20	—			
52,5	≥ 20	—	≥ 52,5	≥ 45	
52,5 R	≥ 30	—			

### 2.2.2 Setting time

The setting time shall be at least 60 minutes for all types of cement and strength classes 32.5 and 42.5. In the case of cement having strength classes of 52.5, the setting time shall be at least 45 minutes. See also Table 2.

### 2.2.3 Soundness

For all types of cement and strength classes, the soundness shall not exceed 10 mm, as determined in accordance with EN 196 - 3. See also Table 2.

## 2.3 Chemical properties

Table 3 shows the requirements in respect of chemical properties. In addition, the requirements in respect of composition, as set out in ENV 197 - 1, Section 4, shall be fulfilled.

**Table 3: Requirements for chemical properties in accordance with ENV 197 - 1**

Property	Test reference	Cement type	Strength class	Requirements <sup>1)</sup>
Loss on ignition	EN 196-2	CEM I CEM III	All classes	$\leq 5,0 \%$
Insoluble residue	EN 196-2	CEM I CEM III	All classes	$\leq 5,0 \%$
Sulphate (as SO <sub>3</sub> )	EN 196-2	CEM I CEM II <sup>2)</sup>	32,5 32,5 R 42,5	$\leq 3,5 \%$
		CEM IV CEM V	42,5 R 52,5 52,5 R	$\leq 4,0 \%$
		CEM III <sup>3)</sup>	All classes	
Chloride	EN 196-21	All types <sup>4)</sup>	All classes	$\leq 0,10 \%$
Pozzolanicity	EN 196-5	CEM IV	All classes	Satisfies the test

- 1) The requirements are given as percentages by mass.
- 2) This indication covers cement types CEM II/A and CEM II/B, including Portland composite cements containing only one other main constituent, e.g. II/A - S or II/B - V, except type CEM II/B - T, which may contain up to 4.5 % SO<sub>3</sub> for all strength classes.
- 3) Cement type CEM III-C may contain up to 4.5 % SO<sub>3</sub>.
- 4) Cement type CEM III may contain more than 0.1% of chloride, but in case the actual chloride content must be declared.

### 3. Low-alkali cement (LA)

Low-alkali cement shall fulfil the requirements set out in Table 4, when tested in accordance with the requirements of EN 196 - 21. (Equivalent  $\text{Na}_2\text{O} = \text{Na}_2\text{O} + 0.658 \text{K}_2\text{O}$ )

**Table 4: Requirements for low-alkali cement**

Cement type	Requirement
CEM I, CEM II/A-S, CEM II/B-S, CEM II/A-V and CEM II/B-V CEM III/A (based on granulated blast furnace slag) <50 % slag	Equiv. $\text{Na}_2\text{O} \leq 0,6\%$
CEM III/A (based on granulated blast furnace slag) $\geq 50$ % slag	Equiv. $\text{Na}_2\text{O} \leq 1,1\%$
CEM III/B	Equiv. $\text{Na}_2\text{O} \leq 2,0\%$

### 4. Sulphate-resistant cement (SR)

Sulphate-resistant cement shall fulfil the requirements as shown in Table 5 when tested in accordance with EN 196 - 2 (calculations in accordance with ASTM C150).

**Table 5: Requirements for sulphate-resistant cement**

Cement type	Requirement
CEM I	$C_3A \leq 3,5\%$
CEM II/A-S and CEM II/B-S CEM II/A-V and CEM II/B-V CEM III/A and CEM III/B (based on granulated blast furnace slag) <70 % slag	As indicated by special investigation
CEM III/B (based on granulated blast furnace slag) $\geq 70$ % slag	--

## Marking

Packaging and delivery notes shall be provided with such marking that the products can be identified.

Deliveries of approved-manufactured products shall be accompanied, at the time of delivery, by delivery notes including at least details of the following:

- SP's certification mark, the P-symbol
- Indication of the type of the cement, in accordance with the example shown below
- The manufacturer, place of manufacture and marking that permits identification of the batch
- Place from which delivered
- Method of delivery and size of the load
- Number of the certificate.

The marking shall indicate the type and class of cement, in accordance with ENV 197 - 1, and other properties in accordance with Appendix 1.

The following example,

**CEM I 42.5 R SR/LA**

relates to a rapid-hardening, sulphate-resistant and low-alkali Portland cement.

Only products covered by approved manufacturing inspection, and which fulfil the requirements for P-marking, may be accompanied by an advice note displaying the P-symbol.



## Marking

Packaging and delivery notes shall be provided with such marking that the products can be identified.

Deliveries of approved-manufactured products shall be accompanied, at the time of delivery, by delivery notes including at least details of the following:

- SP's certification mark, the P-symbol
- Indication of the type of the cement, in accordance with the example shown below
- The manufacturer, place of manufacture and marking that permits identification of the batch
- Place from which delivered
- Method of delivery and size of the load
- Number of the certificate.

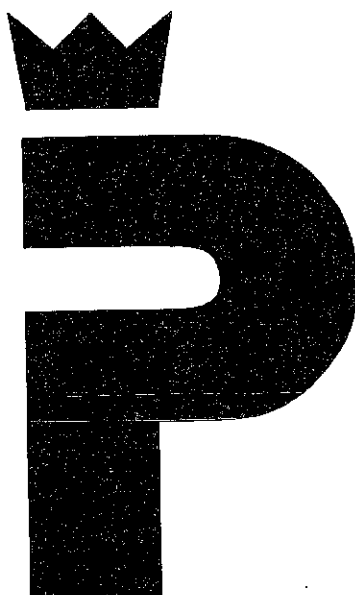
The marking shall indicate the type and class of cement, in accordance with ENV 197 - 1, and other properties in accordance with Appendix 1.

The following example,

**CEM I 42.5 R SR/LA**

relates to a rapid-hardening, sulphate-resistant and low-alkali Portland cement.

Only products covered by approved manufacturing inspection, and which fulfil the requirements for P-marking, may be accompanied by an advice note displaying the P-symbol.



## **Agreement concerning inspection of products certified by SP**

This agreement replaces the earlier agreement dated .....

The following agreement has this day been reached between SP and the holder of the certificate, hereinafter referred to as the manufacturer.

### **1. The inspected product**

The inspected product is defined in the attached appendix.

### **2. Purpose of inspection**

The purpose of inspection is to ensure that certified products comply with current certificates and certification rules, SPCR.

### **3. Application of inspection**

Inspection comprises in-house inspection performed by the manufacturer and supervisory (monitoring) inspection performed by SP. Details of inspection are described in separate documents, listed in Appendix 1.

SP will submit written reports on the results of its supervisory (monitoring) inspection. Points noted in the reports shall immediately be rectified by the manufacturer.

### **4. Costs**

Costs for inspection in accordance with this agreement, and associated necessary tests, shall be met by the manufacturer. SP's General Terms and Conditions also apply in addition to the terms of this agreement.

### **5. Validity of this agreement**

This agreement comes into force when it has been signed by both parties. Notice of termination can be given by either party, and shall be lodged in writing. The agreement shall cease to apply three months after giving of such notice. Two copies of this agreement have been drawn up and signed, with SP taking one and the manufacturer the other.



**6. Special conditions for validity of permission to use the P-symbol**

The manufacturer undertakes that if permission to use the P-symbol should be withdrawn, and subject to a penalty of SEK 200 000:-, immediately to cease to cite SP's certification symbol or to apply the symbol.

Borås,

Astad,

SP  
Building technology

AB Astads Produkter

XX

XX  
(for manufacturer)

**Appendices**

Appendix 1: List of products, certificates and inspection descriptions.

Appendix 2: Places of manufacture and representatives of the company.

**Appendix 1 to agreement****List of products (example)**

Product-type	Product-name	Certificate no.	Certification body	In-house inspection described in document	Supervisory inspection described in document
Cement	CEM X	XXXXXXXX	SP	'Manual for P-marking of cement' dated	SP Report 1993:56

Place of manufacture, contact person etc., see Appendix 2

Astad,

AB Astads Produkter

XX

## Appendix 3.4

Appendix to agreement

### **Place of manufacture and company representative**

Manufacturer:

Address and telephone:

Manufacturing site:

Address of stores:

### **Representative of the company**

Name:

Telephone:

(manufacturer)

