

CEN/TC 104/SC 1/TG 10 „Conformity Evaluation“

TG10-102 [\(ERMCO ETC16/012\)](#)

- Draft -

Version: 21 January 2011

For CEN TC 104 SC1 to decide upon what should be included in the 2010-revision of EN 206-1 regarding factory production control and conformity evaluation.

Remark: Decisions to be taken by TG 18 'Ed. Panel' in italic and red letters.

Remark: After the TG 10 meeting on 21 January 2011 two further proposals were submitted:

- a) Editorial: improved wording in 8.2.1.3.2, method B, assessment period for high and low rate of 'testing' instead of 'production'*
- b) Technical: Annex XYZ.3 for shewhart charts redrafted with fixed estimated sigma*

Draft TG 10 proposals for 2010 revision of EN 206-1

3.x.1 Production day

Day during which a concrete family or a designed concrete that is outside of a family is produced

3.x.2 Document

Information and its supporting medium. The medium can be paper, magnetic, electronic or optical computer disc, photograph or master sample or a combination thereof"

3.x.3 Average Outgoing Quality (AOQ)

Percentage of the unknown distribution below the required characteristic value multiplied by the corresponding acceptance probability of that distribution when using the applied conformity assessment

NOTE: In the case of strength, the word 'required' refers to the characteristic strength for the specified compressive strength class or the characteristic strength of the reference concrete.

3.x.4 Average Outgoing Quality limit (AOQL)

Average maximum fraction below the required characteristic value in the accepted (or outgoing) concrete production.

3.x.5 Average Quality Level(AQL)

Percentage of the unknown distribution worse than the specified characteristic of the property under consideration that is considered satisfactory over a production.

5.4.1 Consistence

Decision by TG 18 Ed. Panel: Should this table be moved to section 8?

Table 11 — Tolerances on target values of consistence

Slump			
Target value in mm	≤ 40	50 to 90	≥ 100
Tolerance in mm	± 40 20	± 20 30	± 30 40
Vebe time			
Target value in sec	≥ 11	10 to 6	≤ 5
Tolerance in sec	± 3	± 2	± 1
Degree of compactability			
Target value	≥ 1,26	1,25 to 1,11	≤ 1,10

Tolerance	$\pm 0,1340$	$\pm 0,1108$	$\pm 0,0805$
Flow diameter			
Target value in mm	all values		
Tolerance in mm	± 30 40		

The values given in this table apply except where more stringent values are given in the national provisions valid in the place of use.

Decision by TG 18 Ed. Panel: Should clause 5.4.3 be moved to section 8?

5.4.3 Air content

Where the air content of the concrete is to be determined, it shall be measured in accordance with EN 12350-7 for normal-weight and heavy-weight concrete and in accordance with ASTM C 173 for light-weight concrete. The air content is specified by a minimum value. The lower limit on air content is the specified minimum value -0,5. The upper limit is the specified minimum value +5,0.

5.4.5 Fibre content

Where the fibre content of fresh concrete is to be determined, it shall be taken either as recorded on the print-out of the batch recorder or where recording equipment is not used, from the production record in connection with the batching instruction. The fibre content is specified by a minimum value.

8.2.1.2 Sampling and testing

Table 13 — Minimum rate of sampling for assessing conformity

Production	Minimum rate of sampling		
	First 50 m ³ of production	Subsequent to first 50 m ³ of production ^a	
		concrete with production control certification	concrete without production control certification
Initial (until at least 35 test results are obtained)	3 samples	1 per 200 m ³ or 1 per 3 production days	1 per 150 m ³ or 1 per production day ^c
Continuous ^b (when at least 35 test results are available)		1 per 400 m ³ or 1 per 5 production days ^d	

^a Sampling shall be distributed throughout the production and should not be more than 1 sample within each 25 m³.
^b Where the standard deviation of the last 15 or more test results exceeds the upper limits for s_n according to table ## , the sampling rate shall be increased to that required for initial production for the next 35 test results.
^c Except where the production is under 20m³/per day. If for organisational reasons the producer is unable to sample this low volume of production, this concrete shall be sampled and tested on the next production day.
^d Or seven consecutive calendar days

8.2.1.3 Conformity criteria for compressive strength

8.2.1.3.1 Criteria for individual results

Conformity of concrete compressive strength is assessed on specimens tested at 28 days¹ in accordance with 5.5.1.2. Each individual test result, f_{ci} , shall satisfy:

$$f_{ci} \geq (f_{ck} - 4)\text{N/mm}^2$$

8.2.1.3.2 Criteria for mean results

The achievement of the specified characteristic strengths shall be assessed by one of the following methods.

Method A: Initial production

For initial production, the mean strength of non-overlapping or overlapping groups of three consecutive results shall satisfy:

$$f_{cm} \geq (f_{ck} + 4)\text{N/mm}^2$$

NOTE The conformity criteria are developed on the basis of non-overlapping test results. Application of the criteria to overlapping test results increases the risk of rejection.

Method B: Continuous production

Method B is an option when conditions of continuous production are established.

Conformity assessment shall be made on test results taken during an assessment period that shall not exceed the period given by one of the following options depending on the rate of testing:

- for plants with lower testing rates (number of test results for designed concrete less than 35 per three months), the assessment period shall comprise at least 15 and not more than 35 consecutive results taken over a period not exceeding 12 months.
- for plants with higher testing rates (number of test results for designed concrete 35 or more per three months) the assessment period shall not exceed three months.

The mean strength of non-overlapping or overlapping groups of consecutive test results obtained from a single concrete or a concrete family in an assessment period shall satisfy:

¹ If the strength is specified for a different age the conformity is assessed on specimens tested at the specified age.

$$f_{cm} \geq (f_{ck} + 1,48\sigma) \text{ N/mm}^2$$

Where this method is being applied to a concrete family, the mean of all non-transposed test results (f_{cm}) for a single family member shall be assessed against the criterion given in table 15. Any concrete failing this criterion shall be removed from the family and assessed individually for conformity.

Table 15: Confirmation criterion for family members

Number "n" of test results for compressive strength for a single family member	Mean of "n" results (f_{cm}) for a single family member N/mm ²
2	$\geq f_{ck} - 1,0$
3	$\geq f_{ck} + 1,0$
4	$\geq f_{ck} + 2,0$
5	$\geq f_{ck} + 2,5$
6	$\geq f_{ck} + 3,0$
7 to 9	$\geq f_{ck} + 3,5$
10 to 12	$\geq f_{ck} + 4,0$
13, 14	$\geq f_{ck} + 4,5$

NOTE ## For guidance for the selection of concrete families, see Annex K.

Initially, the standard deviation shall be calculated from at least 35 consecutive test results taken over a period exceeding three months and which is immediately prior to the production period during which conformity is to be checked. This value shall be taken as the estimate of the standard deviation (σ) of the population for the conformity assessment, but the validity of the adopted value shall be verified during the assessment period. The current estimate of the standard deviation may be applied to the following assessment period, provided the standard deviation of the latest n results (s_n) does not deviate significantly from the current estimate. This is considered valid provided:

$$\sqrt{\frac{\chi_{0,025;n-1}^2}{(n-1)}} \sigma \leq s_n \leq \sqrt{\frac{\chi_{0,975;n-1}^2}{(n-1)}} \sigma$$

being $\chi_{\alpha;v}^2$ the α -fractile of a chi-square distribution with $v = n-1$ degrees of freedom. For $n = 15, 20, 30$ and 35 results the above expression yields the values as given in the following table.

Table ##: Values for verification of standard deviation

Number of test results	Limits for s_n
15	$0,63 \sigma \leq s_{15} \leq 1,37 \sigma$
20	$0,68 \sigma \leq s_{20} \leq 1,31 \sigma$
30	$0,74 \sigma \leq s_{30} \leq 1,26 \sigma$
35	$0,76 \sigma \leq s_{35} \leq 1,24 \sigma$

Where the value of s_n lies outside these limits, a new estimate of σ shall be determined from the last available 35 test results and applied to the assessment period that is about to commence.

NOTE 1 Any revised estimated standard deviation is not applied retrospectively to the previous assessment period.

Method C: Use of control charts

Method C is an option for assessing conformity by the use of control charts when conditions of continuous and stabilized production are established and where the concrete production is covered by third party certification or where there is an explicit agreement between the specifier and the producer to adopt this method.

The control system shall comprise the application of a recognized model of control chart and have the following characteristics:

- achieve a maximum average outgoing quality (AOQ) not exceeding 5,0%;
- aim to ensure conformity of the relevant production with the required characteristic strength;
- include regular monitoring of strength and standard deviation or deviations from target values;
- where applicable, include one or more procedures for speeding the response of the system (e.g. use of early strength data, use of concrete families);
- define and apply clear decision rules for conformity and warning limits;
- document how the system achieves a maximum average outgoing quality (AOQ) not exceeding 5,0% (unless the example procedure -in Annex XYZ is applied)
- when the control chart shows that the standard deviation is $\geq 0,5 \text{ N/mm}^2$ above the currently applied value, change the applied value.

NOTE 1: As a control chart comprises successive sampling plans (with a known standard deviation), the operating-characteristic curve of the individual sampling plan may be established. The AOQ curve is then determined by multiplying each percentage of all possible results below the required characteristic strength in the production by the corresponding acceptance probability.

NOTE 2: Annex XYZ gives a method of application for cusum control charts and for Shewhart control charts with examples of conformity rules that achieve an average outgoing quality limit not exceeding 5,0%. Guidance on values other than those given in Annex XYZ are given in [1] which for cusum control charts is based on [2].

8.2.2 Conformity control for tensile splitting strength

8.2.2.1 General

Clause 8.2.1.1 applies, but the concept of concrete families is not applicable. Each concrete composition shall be assessed separately.

8.2.2.2 Sampling and testing plan

Clause 8.2.1.2 applies.

8.2.2.3 Conformity criteria for tensile splitting strength

Where tensile splitting strength of concrete is specified, conformity assessment shall be made on test results taken during an assessment period that shall not exceed the period given by one of the following options depending on the rate of production.

Where for plants with lower rate of production the number of test results per three months for designed concrete is not greater than 35, the assessment period shall comprise at least 15 and not more than 35 consecutive results taken over a period not exceeding 12 months.

Where for plants with higher rate of production the number of test results per three months for designed concrete exceeds 35, the assessment period shall not exceed three months.

Conformity of concrete tensile splitting strength is assessed on specimens tested at 28 days, unless a different age is specified in accordance with 5.5.1.3 for:

- groups of “*n*” non-overlapping or overlapping consecutive test results f_{tm} (criterion 1);
- each individual test result f_{ti} (criterion 2).

Conformity with the characteristic tensile splitting strength (f_{tk}) is confirmed if the test results satisfy both the criteria in table 16 for either initial or continuous production as appropriate.

Table 16 — Conformity criteria for tensile splitting strength

Production	Number “ <i>n</i> ” of results in the	Criterion 1	Criterion 2
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	group	Mean of "n" results (f_{tm}) in N/mm ²	Any individual test result (f_{ti}) in N/mm ²
Initial	3	$\geq f_{tk} + 0,5$	$\geq f_{tk} - 0,5$
Continuous	Not less than 15	$\geq f_{tk} + 1,48 \sigma$	$\geq f_{tk} - 0,5$

The provisions for the standard deviation given in clause 8.2.1.3.2, Method B shall be applied accordingly.

8.2.3 Conformity control for properties other than strength

8.2.3.1 General

The conformity of the consistence and the air content of air entrained concrete shall be verified by testing at a rate not less than that given in table 18.

NOTE 1 Where in addition identity testing of a defined volume of concrete from a population verified as conforming to the requirements for concrete consistence or air content of fresh concrete or the specified minimum value of fibre content is to be assessed, e.g. if there is doubt about the quality of a batch or load or if in special cases required by the project specification, this procedure is covered by Annex B.

NOTE 2 The conformity criteria for an individual batch and the identity testing criteria are the same.

8.2.3.2 Sampling and testing plan

Batches for testing shall be randomly selected and the samples of concrete taken in accordance with EN 12350-1. Sampling shall be carried out on each family of concrete produced under conditions that are deemed to be uniform. The minimum number of samples and the methods of test shall be in accordance with table 17 or table 18 as appropriate.

8.2.3.3 Conformity criteria for properties other than strength

Where other properties of concrete are specified, conformity assessments shall be on the basis of individual loads for values for consistence, air content and homogeneity of fibre distribution in fresh concrete. For the other properties conformity assessments shall be made on running production over the assessment period that shall not exceed the last twelve months.

Conformity with the required property is confirmed where both

- the number of test results for the property given in table 17 are outside the specified limiting value or class limits or tolerances on target values as appropriate are not greater than the acceptance number in table 19 or, alternatively, the requirement may be based on testing by variables in accordance with ISO 3951:1994 table II-A (AQL = 4 %)
- and individual test results are within the maximum allowed deviation given in table 17 or table 18.

Where the batch has failed the individual criterion, this batch is declared as non-conforming and this result is excluded from any further consideration of conformity of the remaining concrete.

Table 17: Conformity criteria for fibre content, density, maximum water/cement ratio and minimum cement content

Property	Test method or method of determination	Minimum number of samples or determinations	Acceptance number	Maximum allowed deviation of single test results from limit values, tolerance on a target value or the limits of the specified class	
				Lower limit	Upper limit
Steel fibre content of fresh concrete	see 5.4.5	1 determination per day	see table 19	-5% by mass	no limit ¹⁾
Polymer fibre content of fresh concrete	see 5.4.5	1 determination per day	see table 19	-10% by mass	no limit ¹⁾
Density of heavy-weight concrete	EN 12390-7	as table 13 for compressive strength	see table 19	-30 kg/m ³	no limit ¹⁾
Density of light-weight concrete	EN 12390-7	as table 13 for compressive strength	see table 19	-30 kg/m ³	+30 kg/m ³
Maximum Water/cement ratio	see 5.4.2	1 determination per day	see table 19	no limit ¹⁾	+0,02
Maximum Water/(cement + k x addition) ratio	see 5.4.2	1 determination per day	see table 19	no limit ¹⁾	+0,02
Minimum Cement content	see 5.4.2	1 determination per day	see table 19	-10 kg/m ³	no limit ¹⁾
Minimum Cement with k x addition ²⁾ content	see 5.4.2	1 determination per day	see table 19	-10 kg/m ³	no limit ¹⁾
1) Unless limits are specified.					
2) The use of additions shall be in accordance with provisions valid in the place of use.					

Table 18: Conformity criteria for consistence, air content and homogeneity of fibre distribution of fresh concrete

Test method		Minimum number of samples or determinations	Maximum allowed deviation ¹⁾ of single test results from the limits of the specified consistence class	
			Lower limit	Upper limit
Visual inspection of concrete consistence	Comparison of the appearance with the normal appearance of concrete with the specified consistence	each batch; for vehicle deliveries, each load	-	-
Slump classes	EN 12350-2	i) frequency as given in table 13 for compressive strength ii) when testing air content iii) in case of doubt following visual inspection	-10 mm	+10 mm
			-20 mm ²⁾	+20 mm ²⁾
Classes of degree of compactibility	EN 12350-4		-0,03	+0,03
			-0,04 ²⁾	+0,04 ²⁾
Flow classes	EN 12350-5		-10 mm	+10 mm
			-20 mm ²⁾	+20 mm ²⁾
Slump flow classes	EN 12350-8		-	-
Air content of air-entrained fresh concrete	EN 12350-7 for normal-weight and heavy-weight concrete and ASTM C 173 for light-weight concrete	1 sample/production day when stabilised	see 5.4.3	
Homogenous mixing of fibres in fresh concrete where the fibres are added at the truck mixer	as given in annex B.5	frequency as given in table 13 for compressive strength	as given in annex B.5	
NOTES: 1) Where there is no lower or upper limit in the relevant consistence class, these deviations do not apply. 2) Only applicable for consistence testing from initial discharge from truck mixer or agitating equipment (see 5.4.1).				

Table 19: Acceptance numbers for conformity criteria for density, maximum water/cement ratio and minimum cement content

Table 19 AQL = 4 %	
Number of test results	Acceptance number
1 - 12	0
13 - 19	1
20 - 31	2
32 - 39	3

40 - 49	4
50 - 64	5
65 - 79	6
80 - 94	7
95 - 100	8
Where the number of test results exceeds 100, the appropriate acceptance numbers may be taken from table II-A of ISO 2859-1 : 1989	

8.3 Conformity control of prescribed concrete including standardized prescribed concrete

Each batch or load of a prescribed concrete shall be assessed for conformity with the cement content, maximum nominal size and proportions of aggregates if specified and, where relevant, water/cement ratio, quantity of admixture or addition. The amount of cement, aggregate (each specified size), admixture and addition as recorded in the production record or the printout from the batch recorder shall be within the tolerances on the specified values given in table 21, and the water/cement ratio shall be within $\pm 0,04$ of the specified value.

Where conformity of composition is to be assessed by analysis of fresh concrete, the test methods and conformity limits shall be agreed between the user and the producer in advance, taking account of the above limits and the precision of the test methods.

Where conformity of the consistence is to be assessed, the relevant paragraphs of 8.2.3 and table 18 apply.

For the

- cement type and strength class;
- types of aggregates;
- type of admixture or addition, if any;
- sources of concrete constituents, where specified,

the conformity shall be assessed by comparison of the production record and the delivery documents for the constituents with the specified requirements.

9.9 Production control procedures

The constituent materials, equipment, production procedures and concrete shall be controlled with regard to their conformity with the specifications and the requirements of this standard. The control shall be such that significant changes that influence the properties are detected and appropriate corrective action taken.

A procedure shall be put in place to ensure the correct delivery, storage and use of constituent materials including:

- checking that the delivered material is what was ordered;
- checking that it is being discharged into the correct location;
- preventing discharge of any materials that are clearly non-conforming;
- storing materials in a way that minimizes the risk of contamination or deterioration;
- keeping records of deliveries;
- conformity testing of suspect deliveries for all properties for which conformity with the relevant standard or other specification is in doubt,
- checks on the water content of the aggregates.

If a concrete producer produces its own aggregates, the concrete producer shall be regarded as an aggregate producer and shall comply with the technical aspects of the relevant European aggregate standard.

The control of equipment shall ensure that the storage facilities, the weighing and gauging equipment, the mixer and control apparatus (e.g. the measuring of water content of the aggregates) are in good working condition and that they conform to the requirements of this standard. Frequency of inspections and tests for equipment (where used) are given in table 22.

Plant, equipment and transport facilities shall be subject to a planned maintenance system and shall be maintained in efficient working condition so that the properties and the quantity of concrete are not adversely affected.

The properties of designed concrete shall be controlled to the specified requirements as given in table 23.

The proportions of prescribed concrete, its consistence and temperature, where specified, shall be controlled to the specified requirements as given in table 23 (lines 2 to 6 and 9 to 14).

The control shall include production, transport to the point of delivery and delivery.

For some concretes, additional requirements for production control may be necessary. For example in the production of high strength concrete and self-compacting concrete special knowledge and experience are required.. These are not defined in the standard. If the contract has defined special requirements for the concrete, the production control shall include appropriate actions in addition to those in tables 22 and 23.

The actions foreseen in tables 22 to 23, in special cases, may be adapted to the conditions of the specific production place and be replaced by actions which provide an equivalent level of control.

Table 22: Equipment control

	Equipment	Inspection/test	Purpose	Minimum frequency
1	Stockpiles, bins, etc	Visual inspection	To ascertain conformity with the requirements	Once per week
2	Weighing equipment	Visual inspection of the performance	To ascertain that the weighing equipment is in a clean condition and functions correctly	Daily
3		Test of weighing accuracy	To ascertain the accuracy according to clause 9.6.2.2	On installation Periodically ¹⁾ depending on national regulations In case of doubt
4	Admixtures dispenser (including those mounted on truck mixers)	Visual inspection of performance	To ascertain that the measuring equipment is in a clean condition and functions correctly	First use of the day for each admixture
5		Test of accuracy	To avoid inaccurate dispensing	On installation Periodically ¹⁾ after installation In case of doubt
6	Water meter	Test of measuring accuracy	To ascertain accuracy according to clause 9.6.2.2	On installation Periodically ¹⁾ after installation In case of doubt
7	Equipment for continuous measurement of water content of fine aggregates	Comparison of the actual amount with the reading of the meter	To ascertain accuracy	On installation Periodically ¹⁾ after installation In case of doubt
8	Batching system	Visual inspection	To ascertain that the batching equipment is functioning correctly	Daily
9		Comparison (by a suitable method depending on the batching system) of the actual mass of the constituents in the batch with the target mass and in the case of automatic batch recording with the recorded mass	To ascertain batching accuracy according to table 21	On installation In case of doubt Periodically ¹⁾ after installation
10	Testing apparatus	Calibration according to relevant national or EN standards	To check the conformity	Periodically ¹⁾ For strength testing apparatus, at least once per year
11	Mixers (including truck mixers)	Visual inspection	To check the wear of the mixing equipment	Periodically ¹⁾

1) The frequency depends on the kind of equipment, its sensitivity in use and the production conditions of the plant.

Table 23: Control of production procedures and of concrete properties

	Type of test	Inspection/ test	Purpose	Minimum frequency
1	Properties of designed concrete	Initial test (see Annex A)	To provide proof that specified properties are met by the proposed design with an adequate margin	Before using a new concrete composition
2	Water content of fine aggregates	Continuous measuring system, drying test or equivalent	To determine the dry mass of aggregate and the water to be added	If not continual, daily, depending on local and weather conditions more or less frequent tests may be required
3	Water content of coarse aggregates	Drying test or equivalent	To determine the dry mass of aggregate and the water to be added	Depending on local and weather conditions
4	Water content of fresh concrete	Check of the quantity of water added ²⁾	To provide data for the water/cement ratio	Every batch or load
5	Chloride content of concrete	Initial determination by calculation	To ensure that the maximum chloride content is not exceeded	When performing initial test In case of an increase in the chloride content of the constituents
6	Consistence	Visual inspection	For comparison with normal appearance	Each batch or load
7		Consistence test according to EN 12350-2, -3, -4 or -5	To assess the achievement of the specified values of consistence and to check possible changes of water content	Where consistence is specified, as table 13 for compressive strength When testing air content In case of doubt following visual inspections
8	Density of fresh concrete	Density test according to EN 12350-6	For light-weight and heavy-weight concrete for supervision of batching and density control	Daily
9	Cement content of fresh concrete	Check the mass of cement batched ²⁾	To check the cement content and to provide data for the water/cement ratio	Every batch
10	Additions content of fresh concrete	Check the mass of additions batched ²⁾	To check the additions content and to provide data for the w/c ratio (see 5.4.2)	Every batch
11	Admixture content of fresh concrete	Check the mass or volume of admixture batched ²⁾	To check the admixture content	Every batch
12	Water/cement ratio of fresh concrete	By calculation or by test method, see 5.4.2	To assess the achievement of the specified water/cement ratio	Daily, where specified

(continued)

Table 23 (concluded)

	Type of test	Inspection/ test	Purpose	Minimum frequency
13	Air content of fresh concrete where specified	Test according to EN 12350-7 for normal-weight and heavy-weight concrete ASTM C 173 for light-weight concrete	To assess the achievement of the specified content of entrained air	For concretes containing entrained air: first batch or load of each production day until values stabilise
14	Temperature of fresh concrete	Measure temperature	To assess the achievement of the minimum temperature of 5 °C or specified limit	In case of doubt Where temperature is specified: periodically, dependent on the situation; each batch or load where the concrete temperature is close to the limit
15	Density of hardened light-weight or heavy-weight concrete	Test according to EN 12390-7 ¹⁾	To assess the achievement of the specified density	Where density is specified, as frequently as compressive strength test
16	Compressive strength test on moulded concrete specimen	Test according to EN 12390-3	To assess the achievement of the the specified strength	Where compressive strength is specified, as frequently as for conformity control, see 8.1 and 8.2.1
¹⁾ May also be tested in saturated conditions, where correlation to oven-dry density is established.				
²⁾ Where recording equipment is not used and the batching tolerances for the batch or load are exceeded, record the batched quantity in the production record.				

Annex A (normative)

Initial test

A.4

Where fibre concrete is to be produced, the initial testing shall verify by testing that the producers documented procedure achieves a homogenous distribution of the fibres throughout the batch. The testing shall satisfy the criteria in annex B.5.

Annex B (normative)

Identity testing

B.1 General

This annex provides details for identity testing as indicated in 8.2.1.1 and 8.2.3.1.

Identity testing indicates whether the defined volume of concrete in question belongs to the same population as that verified as conforming via conformity assessment by the producer.

B.2 Sampling and testing plan

Where identity testing is to be performed, the particular volume of concrete shall be defined, e.g.:

- single batch or load where there is doubt as to the quality;
- the concrete supplied for each storey of a building or group of beams/slabs or columns/walls of a storey of a building or comparable parts of other structures;
- the concrete delivered to a site within one week, but not more than 400 m³.

The number of samples to be taken from a particular volume of concrete shall be defined.

Samples shall be taken from different batches or loads in accordance with EN 12350-1.

Test specimens for compressive strength testing shall be prepared and cured in accordance with EN 12390-2. The compressive strength of the specimens shall be determined in accordance with EN 12390-3. The test result shall be that obtained from the average of the results of two or more specimens made from one sample for testing at the same age. Where the range of the test values is more than 15 % of the mean, the results shall be disregarded unless an investigation reveals an acceptable reason to justify disregarding an individual test value.

Test specimens for testing consistence or air content of fresh concrete shall be taken in accordance with table 18.

B.3 Identity criteria for compressive strength

B.3.1 Concrete under production control certification

Identity of concrete is assessed for each individual strength test result and the average of "n" non-overlapping discrete results as identified in table B1.

Concrete is deemed to come from a conforming population if both the criteria in table B1 are satisfied for "n" results derived from strength tests on samples taken from the defined volume of concrete.

Table B1: Identity criteria for compressive strength

Number "n" of test results for compressive strength from the defined volume of concrete	Criterion 1	Criterion 2
	Mean of "n" results (f_{cm}) N/mm ²	Any individual test result (f_{ci}) N/mm ²
1	Not applicable	$\geq f_{ck} - 4$
2 – 4	$\geq f_{ck} + 1$	$\geq f_{ck} - 4$
5 – 6	$\geq f_{ck} + 2$	$\geq f_{ck} - 4$

NOTE: The identity criteria of table B1 give a probability of 1 % that a conforming concrete volume is rejected.

B.3.2 Concrete not under production control certification

From the defined volume of concrete, at least 3 samples shall be taken for testing.

The concrete is deemed to come from a conforming population if the conformity criteria in 8.2.1.3 and table 14 for initial production are satisfied.

B.4 Identity criteria for concrete consistence and air content

Identity of concrete is assessed for each individual test result as stated in table 18. Concrete is deemed to come from a conforming population if the criteria in table 18 are satisfied for each individual test result derived from tests on samples taken from the defined volume of concrete.

B.5 Identity criteria for fibre content and homogeneity of fresh concrete

B.5.1 Concrete under production control certification

The test procedure for steel fibre content and homogeneity shall be in accordance with EN 14721 with three samples per load.. The test procedure for polymer fibre content and homogeneity shall be in accordance with EN 14488-7 with three samples per load. The three samples shall be taken during unloading from the first, second and last third of the load. Concrete is deemed to come from a conforming population if both criteria in table B.# are satisfied.

Table B#: Combined Identity criteria for fibre content and homogeneity of fresh concrete

Applicable to	Criterion
Each sample	$\geq 0,80$ of the specified minimum value
Average of 3 samples from a load	$\geq 0,85$ of the specified minimum value

B.5.2 Concrete not under production control certification

From the defined volume of concrete, at least 3 test results shall be determined according to Annex ## (or EN #####).

The concrete is deemed to come from a conforming population if the conformity criteria in table 17 and the identity criteria in table B# are satisfied.

Annex XYZ (informative)

Rules of application for 8.2.1.3, Method C

XYZ.1 Introduction

Concrete production is based on the assumption that when the same quantities of constituents of the same type are batched and mixed, the concrete will have the same properties. Control charts use past production data to check if that assumption is correct by comparing what is actually achieved with what is expected. They detect where there has been a significant change in properties that requires corrective action (s).

The following rules of application satisfy the requirements for Method C in **8.2.1.3** for an AOQL of not exceeding 5%.

NOTE: Reference [1] gives guidance on the use of control charts, the background of the suggested acceptance control charts and in particular it gives a range of other options for selecting Cusum V-mask parameters and target values that satisfy an AOQL not exceeding 5%.

XYZ.2 Control based on the cusum system

A cusum control system based on ISO/TR 7871 and having the following characteristics will satisfy 8.2.1.3, Method C:

- where conformity is based on 28-day strengths, a system for predicting 28 day strength from earlier strength testing is recommended. These predicted strength values are then replaced by the actual 28 day strengths when these become available;

NOTE 1: If the early strength testing shows strengths in excess of those required at 28 days, testing at 28 days is not required.

- where appropriate, concrete families may be used;
- continual monitoring and plotting of three properties: mean strength, standard deviation and, where applicable, the correlation between the early strength and 28 day strength data. Conformity is based on mean strength only;
- target mean strength set at a level $\geq (f_{ck} + 1,96 \sigma)$;
- minimum estimated standard deviation of $3,0 \text{ N/mm}^2$;
- the V-mask for mean strength (for conformity/non-conformity) has only an upper limb with a decision interval of 9σ and a gradient of $0,5\sigma$ and a length of 35 results;
- the V-mask for warning lines has an upper and lower limb. Appropriate warning lines for mean strength and correlation are given by a decision interval of $8,1\sigma$ and a gradient of $\sigma/6$.

NOTE 2 Crossing such warning lines does not lead to non-conformity.

- conformity/non-conformity is based on actual 28-day strength data and is assessed over the latest 35 test results, not exceeding 12 months;
- when the cusum plot for mean strength crosses the non-conformity line, non-conformity is declared on the assessed 35 test results, unless it can be shown that the non-conformity declaration is due to some specific low strength results in which case the non-conformity declaration can be limited to the period in which these low strength results occur;

Where the actual mean strength is shown to be higher than the target mean strength or the actual standard deviation is lower than the current value, changes to the mix proportions are optional.

XYZ.3 Control based on Shewhart charts with modified limits by variables

ISO 8258 gives general information on Shewhart control charts and ISO 7966 gives general information on Shewhart control charts for acceptance control. Shewhart control charts with modified limit by variables are a specific application of these charts where the aim is to assess that the production is higher than a required characteristic value.

Further, the Shewart control charts will have the following characteristics:

- where appropriate, concrete families may be used;
- - continual monitoring and plotting of two properties: mean strength and standard deviation. Conformity is based on mean strength only;
- minimum estimated standard deviation of 3,0 N/mm²;
- non-conformity will be declared when the average of n measured strength results is lower than a lower line L_l situated at a given distance from f_{ck} with:

$L_l \geq f_{ck} + (q_n \cdot \sigma)$ where

- q_n depends on n and on the AOQL chosen,
- σ is an estimated standard deviation, controlled by the control chart for standard deviation

In case $15 \leq n \leq 35$ and $q_n \geq 1.48$, the Shewart charts will satisfy the requirements of 8.2.1.3.2, Method C.

- conformity/non-conformity is based on actual 28-day strength data and is assessed over the latest n test results, not exceeding 12 months.

Annex XXYYZZ (informative)

In the mandatory Spanish Regulation (Instrucción de Hormigón Estructural (*in English: Structural Concrete Code*), approved 18 July 2008 by Royal Decree 1247/2008), there is the requirement for the consumer risk to be not greater than 50% where the population in the assessment period has exactly 5% of all possible results below the characteristic strength. Alteration of this national regulation is outside of the competence of CEN/CENELEC members. For the application of EN 206-1 in Spain the National regulation remains valid and Spain is free to use different coefficients in formulation presented in section 8.2.1.3.2 (method B).

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