Test Equipment

User Manual

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TESTING METHODS FOR RAW MATERIALS AND PRODUCTS IN AAC MANUFACTURING

Guide line for the quality control of raw materials and products

Knowledge is of no value unless you put it into practice.

Anton Chekhov

TEST EQUIPMENT

Preface

The present handbook contains a set of testing methods which represents the basics of the routine activity in the laboratory of an AAC factory.

The goal of these tests is to generate information about the used raw materials and manufactured products in order to create a database, which is a reliable and valuable tool in case of process trouble shooting or the estimation of the scattering of some raw material properties.

The product tests provide information about the compressive strength and the dry density of the manufactured products. The test results indicate if the requirements of the standards are fulfilled or the declared product parameters were achieved.
Dry density and compressive strength and the external quality of the products respectively represent sensitive indicators which clearly signalize if the production processes are under control or corrective action should be taken.

In this context the activity of the laboratory must be especially highlighted. Systematically and precisely performed tests generate reliable information, which are necessary for the process control. In annex 1 a set of laboratory forms are proposed.

The enclosed table shows an overview of the proposed scope of testing. The table indicates for each raw material the tests, which can be performed by using the recommended testing equipment.

Test method		Raw materials						
		burnt lime	cement	sand	ground sand	return slurry	fly ash	ground gypsum
TM1	wet slaking curve	+						
TM2	wet sieve residue	+						
TM3	total CaO	+						
TM4	sieve analyses (air jet)	+	+		+		+	+
TM5	cement setting		+					
TM6	grain size distrib. (sieve shaker)			+				
TM7	density slurry				+	+		
TM8	SO_3-content				+			
TM9	water absorption						+	
TM10	bulk density						+	
TM11	pH - value				+			
TM12	humidity / water content			+	+	+	+	
TM13	LOI	+					+	+
TM14	elutriable fractions			+				

TM21	Determination of the dry density
TM22	Determination of the comressive strength
TM23	Determination of the dimensions, the flatness and the plane parallelism of AAC blocks

The chapter 3 contains a selection of supplementary tests for raw materials and products, which are recommended to complete the level of knowledge about the raw materials and the products especially. These supplementary tests cannot be performed with the available testing equipment. It is necessary to charge specialized institutes with the execution of this tests. The tests request expensive equipment and highly specialized operators, conditions which cannot be efficiently fulfilled in the laboratory of an AAC plant.

TESTING METHODS USED IN AAC PRODUCTION

1. TESTING METHODS FOR RAW MATERIALS USED IN AAC PRODUCTION

1.1 Testing method: TM1 - Determination of the wet slaking curve for ground lime

The present testing procedure for the determination of the wet slaking curve of ground lime is based on the European Standard EN 459–2.

Purpose of the test

The purpose of the test is to determine the reaction speed of the ground burned lime with water.

Required testing equipment:

- Dewar vessel, capacity 1000 ml, e.g. supplied by KGW, Karlsruhe, Germany
- Flat, two winged agitator out of plastic, Ø 60 mm, plastic lid with drill hole for the thermocouple and folding segment.
- Stirring device able to generate 300 rpm.
- Temperature sensor (Pt100) with short reaction time.
- Data logger for the registration of the measuring results.

Testing principle

The temperature development in time caused by the exothermic slaking reaction of the burned lime is recorded.

Burned lime reacts violently with water generating thermal energy. Deviations from the lime/water ratio mentioned in the present testing method and mainly the use of water with higher initial temperature may lead to the boiling of the suspension. Furthermore burned lime and slaked lime are both strongly caustic. The contact with the skin and the eyes must be avoided.

Sampling:

The sample should be representative for the entire batch. The sample should be kept in an air-proof vessel. The test of the sample should be performed as soon as possible.

Performing the test:

The testing equipment and the sample should be kept at an environmental temperature of 20°C. 600 ml distillated water with a temperature of 20°C should be transferred into the Dewar vessel. Through the drill hole of the plastic lid fixed on the

Dewar vessel the thermo couple is immersed at 160 mm from the top of the lid. The agitator is centered and located 5 mm above the bottom of the Dewar vessel. After starting the stirring device the temperature of the water must be about 20±0.2 °C. Shortly before the start of the temperature measurement the lime sample of 150g is added in one batch to the water while the stirrer is running. Immediately afterwards the folding segment of the lid must be closed. The measurement is considered finished, when the measured temperature starts to sink. Generally a measurement lasts about 60 minutes.

Presentation and evaluation of the test results:

From the recorded values the temperatures measured after 2, 5, 10, 15, 20, 30 and 40 minutes are selected. Moreover the time in minutes when a temperature of 60°C (t_{60}) is reached and the time in minutes when the reaction is considered finished (t_{end}) are recorded.

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- date of testing
- the temperature development curve and the selected temperatures after 2, 5, 10, 15, 20, 30 and 40 minutes
- the t_{60} (minutes)
  and
- the t_{end} (minutes) respectively.

This information will be transferred in the data sheet for lime testing in the annex 1.

1.2 Testing method: TM2 - Determination of the wet sieving residue of ground lime

Purpose of the test

The purpose of the test is to determine the agglomeration behaviour of the ground lime during the slaking process.

Required testing equipment:

- Sieve 0,090 mm
- Sieve bottom with water drain
- Collecting vessel
- Precision scale, weighing range 2000g, reading accuracy: 0,1 g
- Drying oven

Testing principle

The wet sieving residue on the 90 µm sieve of the slaked lime is determined. The determined sieving residue is related to the weighted sample.

Burned lime and slaked lime are both strongly caustic. The contact with the skin and the eyes must be avoided.

Sampling:
As sample the slaked lime will be taken from the slaking reactivity test.

Performing the test:
The sample should be taken immediately after finishing the slaking test. The residue on 90 µm sieve is determined by sieving the lime slurry. The lime suspension is poured onto the sieve and flushed with water until the flushing water, leaving the sieve bottom, is clear. The flushing of the residue should be done with a flask or a shower. Overnight the residue and the sieve will be dried in a drying oven at 105°C. After cooling down to environmental temperature the sample is weighed next day.

Evaluation of the test results:
w% wet sieving residue = [(sieving residue $_{dry}$) / (weighted sample $_{dry}$)] * 100 [%]

Registration of the results:
The test record contains the following data:
- date of sampling
- place of sampling
- date of testing
- sieving residue in w%.

This information will be transferred into the data sheet for lime testing in annex 1.

1.3 Testing method: TM3 - Determination of the total CaO content of lime

Purpose of the test
The purpose of the test is to determine the CaO + MgO content of the burned lime.

Required testing equipment:
- 2 burettes, volume: 50 ml
- 1 conical flask, volume of 300 ml
- 1 heating plate
- 1 analytical balance, precision: 0,001g
- Hydrochloric acid, concentration 1n
- Sodium hydroxide solution, concentration 1n
- Colour- indicator-titration phenolphthalein (dissolved in ethanol).

Testing principle
Titration with hydrochloric acid, back titration with sodium hydroxide solution until change of colour of the indicator.

The hydrochloric acid and the sodium hydroxide solutions are both strongly caustic. The contact with the skin and the eyes must be avoided.

Sampling:
The sample should be representative for the entire batch. The sample should have analytical fineness (100 %w < 63 µm).

Performing the test:
An average lime sample of about 1g, weighed with analytical precision (0,001g) is added to the conical flask which contains about 100 ml of demineralised water. The lime and water are intensively homogenized. All the lime must be mixed up with water. Lime particles sticking to the wall of the flask are not admitted.

After adding exactly 40 ml of 1n hydrochloric acid the flask is put on the heating plate and liquid is heated up until soft boiling up. After a 4 minute boiling time the wall of the flask will be flushed from the inner side with 50 ml cold demineralised water. Afterwards the conical flask and its content is kept to cool down at room temperature. After adding 3-5 drops of the colour indicator, the excess of acid is back titrated with the 1n sodium hydroxide solution until the colour of the flask content turns from colourless to red.

After the addition of 1 drop of 1n hydrochloric acid the colour of the liquid in the flask must turn to colourless.

Evaluation of the test results:
$\%\ CaO_{tot} = [2{,}804 * (40.0 - a)] / E * 100\ [\%]$

a: consumption of 1n sodium hydroxide solution, ml
E: weighted sample, g

Required testing equipment:
The test record contains the following data:
- date of sampling
- place of sampling
- % CaO_{tot}.

This information will be transferred to the data sheet for lime testing in annex 1.

1.4 Testing method: TM4 – Sieve analyses

Purpose of the test
The purpose of this test is to determine the fineness (expressed as the passing, w% through a certain sieve) of a ground raw material.
This testing method is applicable for the following ground raw materials:

- Burnt lime
- Cement
- Gypsum
- Fly ash
- Ground sand.

The sieve sizes specific for each raw material are mentioned in the below table:

raw material	sieve size (mm)				
	0,045	0,063	0,090	0,100	0,200
burnt lime				+	
cement	+				+
ground sand	+	+	+		
fly ash	+				+
ground gypsum				+	

Required testing equipment:

- Analytical test sieves 0,045 mm, 0,063 mm, 0,090 mm, 0,100 mm and 0,200 mm (according to the standard ISO 3310-1)
- Air jet sieving machine (e.g. Siebtechnik, SLS200)
- Industrial vacuum cleaner (1000W)
- Precision scale, weighing range 1000g, reading accuracy 0,1 g
- Soft brush
- Collecting vessel
- Mortar and pistil
- Rubber mallet.

Testing principle

The residue on the 0.045mm, 0.063mm, 0.090mm, 0.100mm and 0.200mm sieve is expressed as the gravimetrically amount of the initial mass of the sample.

Sampling:

The assay should be representative for the entire batch. A special consideration should be accorded to segregation and sedimentation. Wet samples (e.g. sand slurry) must be dried according to the test method TM12 – humidity/water content. Occurring agglomeration must be crushed in the mortar with the pistil.

Performing the test:

1). 25 g of the sample are weighted with a weighing accuracy of 0.1g.
2). The sample is first poured carefully on the finest of testing sieves.
3). The sieve is put on the sieving machine and covered with the lid. The sieving machine is started. Average duration of the sieving is 3 minutes.
4). In case of caking the rubber mallet should be knocked firmly a few times on the lid.
5). The residue of the sieving is weighted.
6). The residue is put on the next coarser sieve. The steps 3 until 5 will be repeated.

Evaluation of the test results:

Sieving residue, w% = a/ E * 100 [%]

a: sieving residue, g
E: weighted sample, g

The sieving passing, w% = 100 – sieving residue, w%

Mistakes and faults

Sieving results are strongly influenced by the following mistakes:
a. The mesh is damaged (e.g. contains holes).
b. The cleaning of the mesh should be done very gently (e.g. ultra sonic bath).
c. The alteration of the mesh makes the sieve unusable.
d. Scale is not properly installed.
e. The sample was not properly dried.
f. The sample contains agglomerations.

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- sieve passing at 0.045mm, 0.063mm, 0.090mm, 0.100mm and 0.200mm.

This information will be transferred to the data sheet of the correspondent raw material in annex 1.

1.5 Testing method: TM5 – Setting of cement

Purpose of the test

The purpose of this test is to determine the setting behaviour of the cement. The beginning and the end of the setting are the most important parameters of the setting behaviour. This testing method is based on the European Standard EN 196-3.

Required testing equipment:

- It is recommended to use an automatic Vicat needle device (e.g. product line B26600 – Form+Test). This device measures automatically with a defined frequency the consistence of the cement paste). As an alternative measurement can also be done manually with the Vicat needle device (according to EN 196-3).
- 1 test sieve (according to DIN 4188-1)
- 1 rubber ring (EN 196)
- Immersion needles (10 mm and 1,13 mm)
- Testing room with environmental temperature of 20°C ± 1°C and a relative air humidity of at least 90%
- A pane of glass sized 12 x 12 cm
- Precision scale, weighing range 2000g, reading accuracy 0,1 g
- 1 mixer (according to EN 196-1)

- 1 scrapper
- 1 stopwatch
- 1 spoon
- 1 evaporating dish.

Testing principle

The setting development of the cement is registered by measuring in time the penetration depth of the testing needle.

Sampling:

The cement and the water for the test must be kept in the testing room at least 24 hours at an environmental temperature of 20°C ± 1°C. The cement paste sample must be kept during testing at an environmental humidity of about 90%.

Sample preparing

About 600g cement is passed through the 0,100 mm sieve. The mass of the passing will be determined and recorded.

Performing the test:

1). The rubber ring and the top side of the glass pane are covered with a thin layer of paraffin wax.
2). A clean immersion needle (10 mm) is put into the needle device. The zero point on the mm scale must be set. The zero point of the automatic needle device must be set.
3). A certain amount of water is poured into the mixing vessel of the cement mixer. E.g. 125 g water at a water/cement-value of 25%.
4). Mixing vessel and blade agitator are fixed in the cement mixer.
5). 500 g cement weighed in the evaporating dish is added within 5 -10 seconds into the mixing vessel. Stopwatch will be started, mixer will be started on level 1 (140rpm).
6). The mixer is running 90 seconds on level 1.
7). The mixer is stopped for 15 seconds. The amount of cement paste will be removed from the upper wall of the mixing vessel and from the mixing pallets and added to the mass of cement paste.
8). The mixing process will be continued on level 1 for another 90 seconds (second 91 - to second 180).
9). The rubber ring is put in the middle of the glass pane and filled slightly overlaying with cement paste using the spoon while the rubber ring is easily shaken.
10). The supernatant cement paste will be removed with the scrapper.
11). The filled rubber ring will be put together with the glass pane under the Vicat needle device.
12). 4 Minutes after mixing start, the immersion needle (10 mm) is moved carefully to the surface of the cement paste. Once the needle touches the surface of the cement paste after a break of 1 second, the needle is released falling into the cement paste.

13). If 30 seconds after the release the immersion needle stops 5 to 7 mm from the glass pane, the cement paste has normal consistency. If the normal consistency was not attained, a new sample of cement paste with more or less water must be prepared. The followings should be considered:
- If the distance from the glass pane is more than 7 mm, the water amount must be increased.
- If the distance from the glass pane is less than 7 mm, the water amount must be decreased.
- The usually required water amount ranges between 115 until 150 cm^3 (23 to 30 w% related to the cement quantity).

14). If the normal consistency was attained, the sample will be centrally positioned under the automatic needle device, a new immersion needle (1,13 mm) will be installed and the measurement will be started after 5 minutes. A measuring interval of 10 minutes will be selected.

15). If the needle stops 3-5 mm from the glass pane the beginning of the setting time was achieved. This moment will be recorded and considering the start of the mixing the time of the setting begin will be calculated and registered in the form sheet.

16). After the setting begin was reached the rubber ring will be turned bottom side up on the glass pane and positioned under the automatic needle device. Same needle (1,13 mm) will be used.

17). The end of the setting is reached, if the needle penetrates only 1 mm into the sample. This moment will also be registered in form sheet. Relating this moment to the starting time of the mixing, the end of the setting can be calculated.

Mistakes and faults

- The penetration needle is twisted.
- The system of levers don´t work properly.

Registration of the results:

The test record contains the following data:
- date of sampling
- place of sampling
- cement type
- class of the compressive strength
- begin of setting (minutes)
- end of setting (minutes)
- water need for normal consistency (w%).

This information will be transferred in the data sheet for cement testing in annex 1.

1.6 Testing method: TM6 – Grain size analysis sand

Purpose of the test

The purpose of this test is to determine the grain size distribution (expressed as the passing, w% through a certain sieve) of sand and granulated materials.

Required testing equipment:

- Analytical test sieves (e.g. Retsch): 3,150 mm / 2,000 mm / 1,000 mm / 0,500 mm / 0,250 mm / 0,125 mm and 0,090 mm (according to the standard DIN 22019, part 1)
- Analytical sieve shaker (e.g. Retsch, AS200)
- Precision scale, weighing range 1000g, reading accuracy 0,1 g
- Soft brush
- Collecting vessel
- Drying oven

Testing principle

The residue on the sieves 3,150 mm / 2,000 mm / 1,000 mm / 0,500 mm / 0,250 mm / 0,125 mm and 0,090 mm and the passing through the 0,090 mm sieve are expressed as the gravimetrically amount of the initial mass of the sample.

Sampling:

The sample should be representative for the entire batch. The sand sample (about 600 g) is dried at 105 °C until constant mass.

Performing the test:

1). The sieves are installed on the sieving machine with increasing sieve size from bottom to top. The finest sieve (0,090mm) is set on a collecting pan.
2). 300 g of the dry sample are weighed with a weighing accuracy of 0.1g.
3). This sample is poured on the top sieve.
4). The sieve fixing cover is put on the top sieve and fixed with the fixing nuts.
5). The sieving machine is plugged.
6). The sieving time (about 15 minutes) and the vibration intensity (amplitude – 1 2 mm) are set.
7). The sieving machine is switched on (switch is on the back side of the machine).
8). The fixing nuts should be retighten if necessary.
9). After the sieving is finished the residue on every sieve and the passing through the 0,090 mm sieve (in the collecting pan) will be weighted.

Evaluation of the test results:

Sieving residue on the sieve xxx, w% = A / E * 100 [%]

Sieving passing through the sieve 0,090 mm, w% = B / E * 100 [%]

A - Sieving residue on sieve xxx, g
B - Sieving passing on 0,090 mm sieve
E - weighted sample, g

The test is valid if the sum of all the residues and the passing through 0,090 mm sieve differs no more than 3 w% from the weighted sample E.

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- sieve passing at 0.090 mm and the residues on the other sieve.

The results are shown in a diagram containing the density curve and the sum distribution curve.

This information will be transferred in the data sheet for the grain size distribution of sand in annex 1.

1.7 Testing method: TM7 - Determination of the slurry density

Purpose of the test

The purpose of the test is to determine the density of slurries (sand slurry, PFA slurry and recycled slurry). The slurry´s density expressed in kg/dm³ - mass per litre – is needed for the calculation of the slurry´s water content.

Required testing equipment:

- 1 laboratory scale, precision: 0,1g
- 1 Measuring cylinder, 1000 ml
- 1 Beaker, 2000 ml

Testing principle

The mass of 1 litre slurry is determined with a precision of 0.1 g.

Sampling:

The sample is taken from the slurry tanks or from the ball mill. The volume of the sample should be around 1500 ml. To avoid sedimentation, the slurry sample will be brought to the laboratory under permanent stirring.

Performing the test:

The dried measuring cylinder is put on the scale and the tare mass is determined. The slurry is filled gently into the cylinder. If the level of the slurry in the cylinder approaches to the 1000 ml mark, the filling operation will be continued very carefully and the attaining of the final mark of the slurry will be decided at eye level.

Evaluation of the test results:

The mass indicated by the scale represents the density or the mass per litre.

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- density (kg/m³).

This information will be transferred in the data sheet for the slurry testing in annex 1.

Annex 1 contains also 3 tables showing the correlation between the density and the water and solid content respectively for sand-, PFA- and recirculated-slurry.

1.8 Testing method: TM8 - Determination of the SO_3 content of the sand slurry

Purpose of the test
The purpose of the test is to determine the SO_3 content of the sand slurry.

Required testing equipment:
- Muffle kiln, temperature till 1100 °C
- 1 analytical balance, precision: 0,01g
- Micro wave oven (household article)
- 1 watch-glas, Ø 200 mm
- Calcination crucible Ø 50 mm, 25 mm height
- Exsiccator.

Testing principle
This method is based on the transformation of calcium sulphate dihydrate to calcium sulphate while heating. The loss on crystal water gives precise information about the concentration of SO_3.

This testing method can be applied only if gypsum is part of the slurry resulted from the common grinding of sand and gypsum.

Performing the test:
1). About 50g sand slurry are put on the watch class and dried in the micro wave oven until constant mass (drying time about 15 minutes, at about 200 Watt).
2). 20 – 30 g of the dried sand is weighed into a calcination crucible.
3). The sample is kept in the muffle kiln for 1 hour at 350°C.
4). Afterwards the sample cools down in the exsiccator containing silica gel.
5). A parallel test is made with the pure, not ground sand.
6). The difference between the LOI of the sand slurry and the sand at 350°C represents the loss of crystal water from the gypsum.
7). If the quality of the sand is quite constant in time, its determination of the LOI at 350 °C can be done occasionally, e.g. once per month.

Evaluation of the test results:
- Ssi - Sand slurry initial mass, g
- Ssf - Sand slurry final mass, g
- Si – Sand initial mass, g
- Sf - Sand final mass, g
- SO_3 – SO_3 content, w%

$$SO_3\ (w\%) = \left(\frac{SSi - SSf}{SSi} - \frac{Si - Sf}{Si} \right) * 100 * 2{,}22$$

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- SO_3 (w%).

These information will be transferred in the data sheet for sand slurry testing in annex 1.

1.9 Testing method: TM9 - Determination of the water absorption of fly ash

Purpose of the test

The purpose of the test is to determine the water quantity which is absorbed by fly ash. This test method is useful to analyse the suitability of the fly ash and for the routine quality control of the fly ash in the laboratory.

Required testing equipment:

- 2 Beakers
- 2 Folded filters
- 2 Hoppers, polyethylene
- 1 Analytical balance, precision: 0,01g
- Drying oven
- Distilled water
- Kitchen timer

Testing principle

Determination of the water absorption of fly ash.

Sampling:

The fly ash should have a moisture content less than 0.5 w%. If the moisture content is higher than 0.5 w% the fly ash samples must be dried at 105 °C until constant mass reached. Before the test, the fly ash sample must be dry, in powder form and at environmental temperature.

Performing the test:

1). 25 ± 0,1g fly ash is weighed in a 600 ml beaker.
2). The folded filter is put into the polyethylene hopper and moistened with distilled water.
3). After the filter is drained (within one minute no water drop will fall from the filter) it will be weighed together with the hopper.
4). 250 ml is added into the beaker with the fly ash. The suspension will be stirred continuously for 5 minutes.
5). The suspension will be transferred entirely on the wet folded filter by flushing with distilled water.
6). After the filter and the sample are drained (within one minute no water drop will fall from the filter), the hopper, the filter and the sample will be weighed.

Evaluation of the test results:

- m1 - mass of the hopper, the filter and the sample - in wet state
- m2 - mass of the hopper and the filter - in wet state

*water absorption (w%)=(m1-(m2+25))*4*

It is recommended to perform a repeat determination. In case the difference between the test results exceeds 10%, a third determination should be done.

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- water absorption (w%).

This information will be attached to the data sheet for fly ash testing.

1.10 Testing method: TM10 - Determination of the bulk density of fly ash

Purpose of the test

The purpose of the test is to determine the bulk density of fly ash. This test is useful to analyse the uniformity of fly ash. It is often used for the laboratory routine quality control.

Required testing equipment:

- 1 measuring cylinder
- 1 spatula
- Sheet of glassine paper
- Analytical balance, precision 0.01g

Testing principle

The mass of a certain volume (e.g. 100 ml) of a powdery sample is determined. The ratio between the mass and the volume represents the bulk density, expressed in kg/m³.

Sampling:

The sample must be powdery.

Performing the test:

1). The tare mass of the measuring cylinder is determined.
2). The measuring cylinder is carefully filled with fly ash. Impacts during filling should be avoided.
3). The filled measuring cylinder is weighed.
4). Steps 2 and 3 will be repeated twice.
5). The average of the three weighings represents the bulk density.

Evaluation of the test results:

$$bulk\ density = \frac{average\ mass}{100ml}\left[\frac{kg}{dm^3}\right] * 1000 = \left[\frac{kg}{m^3}\right]$$

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- bulk density (kg/m³).

This information will be transferred in the data sheet for fly ash testing in annex 1.

1.11 Testing method: TM11 - Determination of the pH-value

Purpose of the test

The purpose of the test is to determine the acid or alcaline properties of water. The result is given as the negative logarithm of the hydrogen ion concentration or rather the hydrogen ion activity. The pH-value of solids always refers to water samples, which resulted from the elution of the solids.

The test is suitable for process water and for water used for steam generation.

Required testing equipment:

- 1 pH meter with temperature compensation
- 1 beaker 200 ml
- Distilled water (50 ml)
- Glass stirrer
- Standard buffer solution for pH = 7
- Standard buffer solution for pH = 4 or pH = 10

Testing principle

The concentration of hydrogen ions in a solution will be determined by measuring the difference of potential on a glass membrane between the solution to be analyzed and a reference solution. By means of a calibration the tension is transformed into the negative logarithm of the hydrogen ions of the solution to be analyzed (pH-value). The pH-value is dimensionless.

Sampling:

The samples should have environmental temperature. Acids and bases having concentrations higher than 1 mol/l must be diluted before ph-Value measuring.

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Bivalent iron ions (Fe++) contained in water samples might change (decrease), in contact with atmospheric oxygen, the pH-value.

In case of solid samples an elution in water is necessary (e.g. according to DIN 38414-4).

Performing the test:

1). The pH-meter should be calibrated minimal once a day before use.
2). The calibration will first be carried out using the standard buffer solution for pH = 7. Calibrating with the standard buffer solution for pH = 4 or pH = 10 the abruptness of the ph-meter´s characteristic will be set.
3). The first calibration will be checked, using the standard buffer solution for pH = 7 again.
4). The steps 2 and 3 will be repeated as long as the difference of the calibration at the two pH-values is less than 0.02.
5). During measuring the measuring electrode with the temperature sensor will be immersed at least 3 cm (until over the glass membrane).
6). The reading of the pH-meter will be performed after 3 minutes, while the sample will be gently swung.
7). Steps 5 and 6 will be repeated once again.
8). The average of the two measurings represents the result.

Evaluation of the test results:

Orientation:

- pH = 7 - neutral
- pH = 0 - strongly acid
- pH = 14 – strongly alkaline

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- pH-value.

This information will be transferred in the data sheet for of the analyzed sample (annex 1).

1.12 Testing method: TM12 - Determination of the humidity

Purpose of the test

The purpose of the test is to determine the adsorptive bound humidity of a sample. The humidity (expressed in w %) will be related to the dry or wet mass depending on the nature of the sample:

- The water content will be related to the wet mass of the sample in case of raw materials (HW).
- The water content will be related to the dry mass of the sample in case of AAC products (HD).

Required testing equipment:

- Analytical balance, weighing accuracy 0,0001g
- 1 spatula
- 1 exsiccator
- 1 porcelain crucible, Ø 5 cm
- 1 drying oven.

Testing principle

The humidity of the sample will be gravimetrically determined, related to the mass of the dry or humid sample and expressed in w%.

Sampling:

The sample must be homogeneous and if necessary ground until it passes entirely through the 5 mm sieve.

Performing the test:

1). 1 until 5 g of the sample is put into the dry porcelain crucible. Higher quantities of sample hinder the drying process. The filled crucible will be dried in a drying oven until constant mass is reached.

If the sample is thermostable it might be dried at 105°C for about 2 hours.

If the sample tends to lose also chemical bound water (gypsum, AAC, etc.) it will be dried at 60°C for about 12 hours.

2). The crucible with the dried sample will cool down in the exsiccator and will be weighted about 30 minutes later.

In order to check the constancy of mass the crucible might be put back into the drying oven at the suitable temperature. After a second cooling down in the exsiccator the sample will be weighted again.

Evaluation of the test results:

The loss of mass might be referred to mass of the dry (HD) or wet sample (HW).

- MCRE – mass of the empty crucible, g
- MCRW – mass of the empty crucible + mass of the wet sample, g
- MCRD – mass of the empty crucible + mass of the dry sample, g

$$HD\ (w\%) = \frac{(MCRW - MCRD)}{(MCRD - MCRE)} * 100$$

$$HW\ (w\%) = \frac{(MCRW - MCRD)}{(MCRW - MCRE)} * 100$$

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- type of raw material
- humidity HD or HW (w%).

This information will be transferred in the data sheet of the tested raw material (annex 1).

1.13 Testing method: TM13 - Determination of the loss on ignition

Purpose of the test

The purpose of the test is to determine the volatile components of a sample. LOI is related to the mass of the dry sample and expressed in w%.

This test is useful to analyse the uniformity of different raw materials used in AAC production. It is often used for the laboratory routine quality control.

Required testing equipment:

- 1 muffle oven
- 1 mortar and pestle
- 250 µm sieve
- Analytical balance, weighing accuracy 0,0001g
- 1 spatula
- 1 exsiccator
- 1 porcelain crucible
- 1 porcelain bowl
- 1 sample divider
- 1 trowel

Testing principle

The sample is calcined at 1000°C. The loss of mass, expressed in w%, is determined after calcination.

Sampling:

The sample must be crushed in a mortar until it passes entirely through the 250 µm sieve.

Performing the test:

1). An average sample will be taken and by means of the sample divider reduced to about 10g.
2). The sample will be dried at 105°C until constant mass (duration usually 2 hours). If the sample tends to lose crystal water, it will be dried until constant mass at 60°C (duration usually 12 hours).
3). The porcelain crucibles will be calcined for 30 minutes at 1000°C. Their cooling down will happen in the exsiccator.
4). The mass of the empty crucible will be determined with an accuracy of 0,001g.
5). About 5 g of the average sample will be weighed with an accuracy of 0,001g.
6). The sample will be calcined at 1000±25°C for at least 2 hours. Calcination time for lime samples will be at least 3 hours.
7). After cooling down in the exsiccator the sample will be weighed.

Evaluation of the test results:

- M1 – mass of the empty crucible, g
- M2 – mass of the empty crucible + mass of the sample before calcination, g
- M3 – mass of the empty crucible + mass of the sample after calcination, g

$$LOI\ (w\%) = \frac{(M2 - M3)}{(M2 - M1)} * 100$$

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- type of raw material, LOI (w%).

This information will be transferred in the data sheet of the tested raw material. See annex 1.

1.14 Testing method: TM14 - Determination of the elutriable fraction (< 0,063 mm)

Purpose of the test

The purpose of the test is to determine the elutriable fractions of sand. The amount of elutriable fractions will be related to the mass of the dry sample and expressed in w%. This test is special for checking the quality of sand.

Required testing equipment:

- 1 round bottom flask
- 63 µm sieve
- Analytical balance, weighing accuracy 0,01g
- Drying oven
- Folded filter, Ø 240 mm
- Funnel
- Plastic pale, 5 litre

Testing principle

The amount of elutriable components of sand sample is determined by weighing.

Sampling:

For the calculation of the elutriable amount, the humidity of the sand must be considered. It is recommended to choose the quantity of wet sand in such a manner, that it should correspond to 200g dry sand.

Performing the test:

1). 200±0.01 g sand in the initial state is weighed with ca. 500 ml tap water in a round bottom flask.
2). The mixture will be suspended strongly and then it rests minimal 4 hours. In between the suspension should be suspended several times.
3). After the waiting period the suspension will be agitated again. After a short break the overlaying suspension will be decanted through a 63 µm sieve in the prepared pale. The sand in the round bottom flask will again be mixed with water, agitated and the overlaying suspension will be sieved until the overlaying water shows no turbidity.
4). The suspension is collected in the pale. Particle > 63 µm are retained by the sieve.
5). The suspension in the pale will be kept overnight; afterwards the clear overlaying water will be decanted. The rest will be filtered through the dry folded filter (previously weighed).
6). The filter including the filtered solid will be dried overnight at 105°C.

Evaluation of the test results:

The amount of elutriable particles expressed in w% results from the ratio between mass of the dried filter including filtered solid and the dry mass of the sand.

Registration of the results:

The test record contains the following data:

- date of sampling
- place of sampling
- type of raw material
- amount of elutriable fraction (w%).

This information will be transferred in the data sheet of the sand in annex 1.

2. TESTING METHODS FOR AAC PRODUCTS

Determination of the dry density and the compressive strength of AAC products.

The present testing procedure for the determination of the dry density and the compressive strength of AAC products is based on the European Standards EN 771 and EN 772. It is recommended to use this testing procedure if there is no national AAC standard available.

If available the national AAC standard will be used with priority.

Testing principle

Six cubes (100x100x100 mm) are cut out of one AAC block. The cubes with polished surfaces will be stored in drying ovens:

- 3 cubes at 105 ±5 °C until a constant mass is reached. The dry density of the samples is calculated knowing the mass and the volume of the cubes.
- 3 cubes at 60 ± 5 °C until a humidity of 6 ± 2 % was reached.

After a cooling down period the compressive strength of the cubes is determined using a compression testing machine.

2.1 Testing method: TM 21 - Determination of the dry density of AAC products

Testing frequency:
For the routine testing one AAC block of each manufactured dry density class is taken from each autoclave after curing is finished.

Required testing equipment:

- Ventilated drying oven, which can maintain an average temperature of 105 ± 5°C for the duration of the test.
- Laboratory balance, range: 6000g, division 0,1gr
- Digital slide gauge with a precision of 0,1mm
- Milling machine (optional)

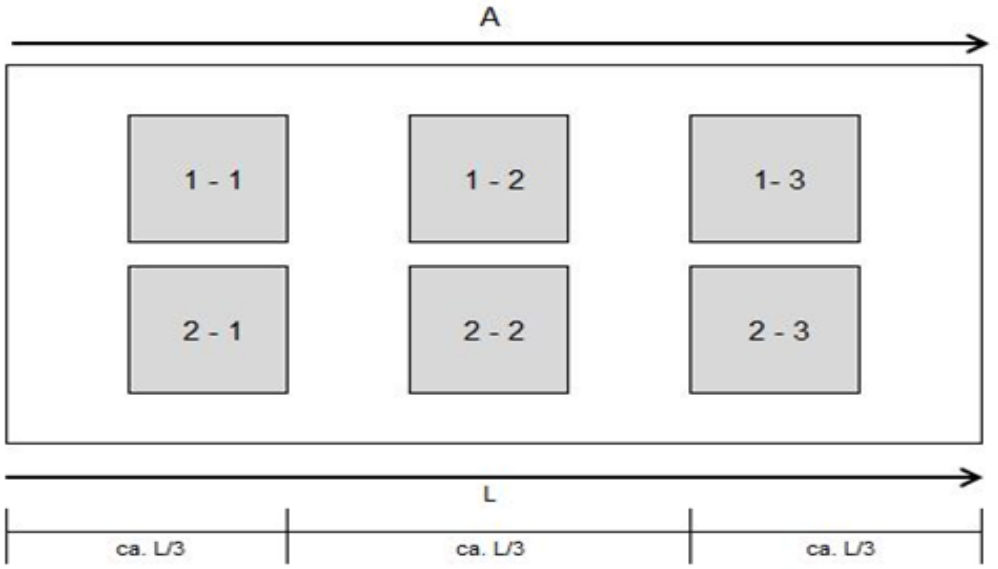
Sampling:
The dry density is tested on 3 pieces of 100 mm cubes.

The cubes (1-1, 1-2 and 1-3) are cut with a band saw out of a block according to the below sketch.

The 6 surfaces of each cube will be manually polished dry or using a milling machine (if available).

The polished surfaces must be plane-parallel and the dimensional deviation at 100 mm should be max 0,1mm.

On the polished cubes the rising direction (A) will be marked.



Key:
A – Rising direction
L – Lengths of AAC block

Performing the test:

The dimensions of the cubes are measured with a digital slide gauge with a precision of 0,1mm. The volume of each cube V_{cd} will be calculated.

The cubes will be dried in a ventilated drying oven at a temperature of 105 ± 5°C until the constancy of the mass, M_{dry} is reached. Constancy of mass is considered reached if the loss of mass between two consecutive massings made in a space of time of 24 hours is less than 0.2 % of the total mass of the cube. The mass of the dried specimen M_{dry} will be determined by weighing.

Presentation and evaluation of the test results:

The dry density ρ_{dry} of each cube will be calculated using the below formula.

$$\rho_{dry} = M_{dry} / (V_{cd} * 10^6), \quad (kg/m^3)$$

ρ_{dry} – dry density, kg/m³
M_{dry} – mass of cube, g
V_{cd} – volume of the cube, cm³

For each block the average dry density will be calculated from the densities of the three cubes.

Registration of the results:

The calculated dry densities and the average value will be entered into the form sheet (see annex 1) together with the production date and the number of casting where the block was taken from.

2.2 Testing method: TM 22 - Determination of the compressive strength of the cubes

Testing frequency:
The testing frequency is similar to 2.1.

Required testing equipment:
The compression testing machine is according to the specification of the EN 772-1, part 6.1. The accurate function of the testing machine will be checked once each two years by authorized companies.

Performing the test:

1). Check of the humidity of the cubes.
In order to determine the mass of the cubes when their humidity is 6 ±2 % the mass of the three dried cubes from the determination of the dry density will be multiplied by 1,06. The result will give the mass of the cubes (2-1, 2-2 and 2-3) at the requested testing humidity of 6 ±2 %.

2). Cooling down of the cubes.
After the cubes attained the mass constancy, they will be left for about 5 hours to reach the environmental temperature.

3). Positioning of the cubes.
The cube will be positioned centrically on the inferior pressure plate of the testing machine. The pressure plates must always be cleaned from the remains of of the previous test.
The cubes will be positioned in such a way, that the rising direction of the AAC block is perpendicular to the direction of the load.

4). Applying the load.
According to the EN 772-1 the recommended speed to increase the load during the test is 0,05N/mm²s at expected compressive strength < 10 N/mm².
It is recommended to maintain a constant loading speed during the test.
The maximum load should be registered.

Presentation and evaluation of the test results:
The compressive strength of each cube is calculated with the following formula:

Compressive strength = Maximum load / testing surface, N/mm²

The surface is calculated by multiplying the length and the width of the testing surface. The result of the test is given with a precision of 0,01N/mm². The average of the compressive strength of the three cubes represents the testing result of the original block.

Registration of the results:
The testing results and the average of the three measured compressive strengths will be entered in the same form sheet, already used for the dry densities (see annex 1).

Remark

For practical reason it is recommended to test the compressive strength on cubes cut from the blocks shortly after unloading autoclaves – “autoclave fresh blocks”. The cubes are cut as usual. Before measuring the compressive strength, the cubes must reach the temperature of the environment and their mass should be determined.
The level of the measured compressive strength is lower because of the higher testing humidity.
The advantage of this method is that measured values of the compressive strength are available within 24 hours. This information permits to take fast corrective action in case of necessity.

This procedure does not replace the regular tests of the compressive strength.

2.3 Testing method: TM 23 - Determination of the dimensions, the flatness and the plane parallelism of the AAC blocks

Purpose of the test

The purpose of the test is to check the dimensional accuracy, the plane parallelism and the flatness of the AAC blocks.
The test procedures are based on the European Standard EN 772 part 16 and 20.
The goal of this test is to control if the products fulfil the requirements which are necessary to permit the use of thin bed mortar (tolerance of the block height < 1mm and flatness / plane parallelism < 1mm).

Required testing equipment:

- Calliper - measuring range 0 – 750 mm, admissible measuring error: max. 0,2 mm
- Steel ruler with graduation, length 800 mm
- Set of feeler gauges

Sampling:

According to the European Standard EN 771–4 the dimensional accuracy should by tested on 6 randomly selected blocks. On the same blocks will also be tested the plane parallelism and the flatness.

Performing the test:

1). Dimensional accuracy

Length, width and height of the blocks will be measured as shown in table 1.

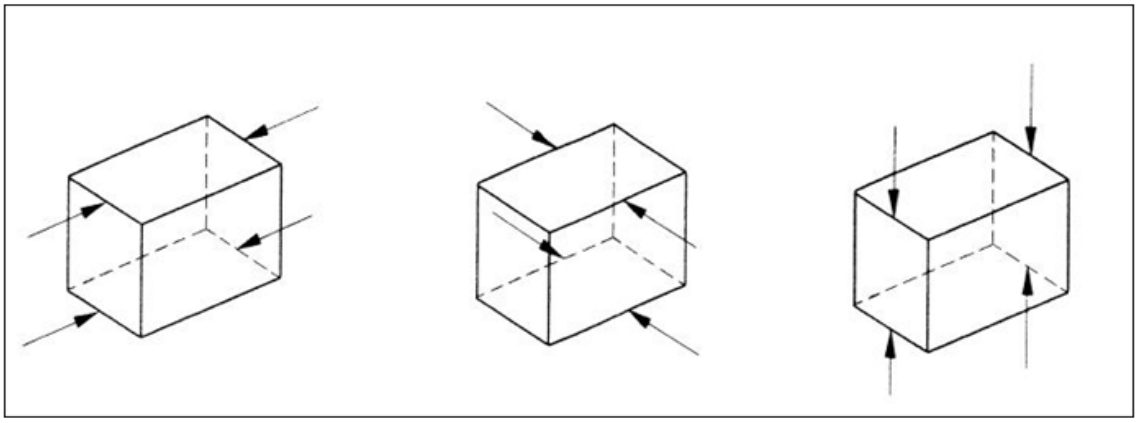


Table 1 – measuring points of the dimensions of the block

2). Flatness

The block will be positioned in a stable position on a flat surface.

Diagonal 1 and diagonal 2 are measured with the steel ruler connecting edge 1 with edge 4 and edge 2 with edge 3 respectively (Table 2).
After measuring the distance between the edges the distance between the ruler and the surface of the block is checked using feeler gauges.

If the surface is convex the ruler will be positioned in such a way, that the distances between the ruler and the surface on both sides of the point of contact shall be approximately equal. Using a feeler gauge the distances will be measured with a precision of 0,1 mm.

If the surface is concave the biggest distance between the ruler and the surface of the block will be measured using a feeler gauge. The result will be rounded at 0,1 mm.

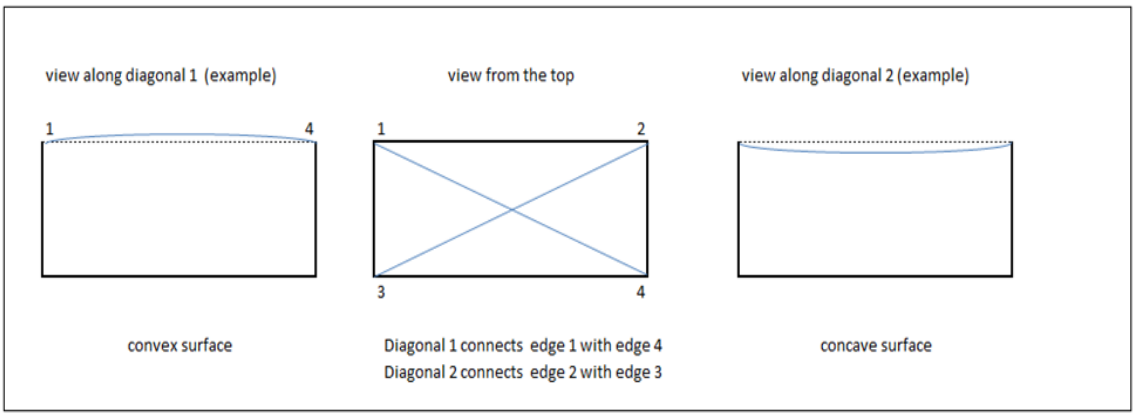


Table 2 - Test of the flatness

3). Plane parallelism

The block will be positioned in a stable position on a flat surface (measuring table).
The distances between the edges are measured according to table 3.

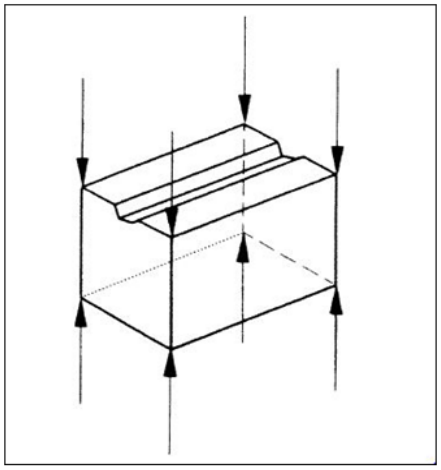


Table 3 – Test of the plane parallelism

Evaluation of the test results:

Dimensional accuracy

From the measured values of the length, width and height of one block average values are calculated. The deviation of the measured values from the target values must satisfy the requirements of the standard.
Table 4 shows the requirements of the European Standard EN 771–4:2003.

Dimensions	AAC units for erection with joints made of		
	General purpose and light ware mortar	Thin layer mortar	
		TLMA	TLMB
Length	3 -5	± 3	± 1,5
Height	3 -5	± 2	± 1,0
Width	± 3	± 2	± 1,5
Flatness	no requirements	no requirements	≤ 1,0
plane parallelism	no requirements	no requirements	≤ 1,0

The requirements for flatness and plane parallelism are stipulated in table 4.

Registration of the results:

The test records contains the following results:

- date of sampling
- place of sampling

Measured values of length, width, height, calculated average values, figures representative for flatness and plane parallelism.

This data should be filled in the form sheet “dimensional accuracy” proposed in annex 1.

3. FURTHER TESTS RECOMMENDED TO CHECK THE QUALITY OF RAW MATERIALS AND OF NON REINFORCED AAC PRODUCTS

3.1 Raw materials

Lime, cement and aluminium powder or paste are finished products. In most of the cases the producers can offer detailed information about the properties of their product. Beside these, some specific suitability tests are performed in the laboratory of the AAC factory. These specifications will characterize relatively good the mentioned raw materials.

Gypsum or anhydrite are still in natural shape. Except for crushing and grinding these raw materials have not suffered changes of their chemical composition.
The LOI performed in the laboratory of the AAC factory gives information about the waste of sample´s mass while heating up to 1000°C. In order to get a more complete image about this raw material it is recommended to check periodically the chemical and mineralogical composition.

Sand is a natural raw material too. Due to the complexity of this raw material and due to the fact, that sand is processed in the AAC factory the information resulting from the tests in the laboratory of the factory should be complemented with the following supplementary tests:
The chemical and mineralogical analyses give information about the content of quartz and the other mineralogical components, like the clay minerals for instance. This test is very useful if new sand quality should be used in production.

In the same situation it is necessary to determine **the absolute density of the sand.** This parameter is needed for the calculation of the sand slurry parameters.

The **grinding of the sand** is a very complex process and has a big influence on the properties of the sand slurry and on the product properties consequently. The grinding of the sand requests high amounts of electrical energy, causing the energy costs to be the most important part of the grinding costs. In order to get more information about the grindability of sand it is recommended to determine the working index of the sand according to the method of Bond. The result of this standardized procedure is a parameter called Bond working index “wi” expressed in KWh/t. The Bond working index represents the energy quantity needed per time unit to ground a material from a defined initial grain size distribution to a defined final grain size distribution. The Bond working index is a useful tool when comparing different raw sand qualities.

3.2 Products

Dry density and compressive strength are the most known and usually tested parameters which give first information about the quality standard of the AAC products. Being used as a modern building material the AAC products must fulfil the requirements of the application technology and maintain their properties over a long period of time.
In addition to the dry density, the compressive strength and the dimensional accuracy it is recommended to check the following parameters periodically:

1). Drying shrinkage
The drying shrinkage describes the dimensional changes of AAC samples during the natural drying process. Depending on the quality of the AAC product the shrinking of the blocks might cause cracks (shrinkage cracks) in erected walls.
The determination of the drying shrinkage is defined in the European Standard EN 680. If the shrinkage determined according to this standard is less than 0,2 mm/m the AAC products are considered of good quality.
The drying shrinkage should be tested for the standard products about 4 times per year. In case of new products the drying shrinkage will be determined as a part of the suitability tests.

2). Mineralogical composition
As known from technical literature all the properties of AAC products are determined by the presence of a group of minerals called calcium silicate hydrates (CSH –phases), which are generated during the hydrothermal reactions in the autoclave. The most important representative of the CSH phases is a mineral called Tobermorite. The amount and the shape of the tobermorite crystals in the AAC product have strong influence on its properties.
The usual method to check the mineralogical composition of AAC is the XRD – analysis (X ray diffraction). Among tobermorite this method permits to identify other minerals, like Portlandite, Calcite and others. Most of them give significant information about the properties of the AAC product.
The mineralogical analysis of the AAC products should be performed in combination with the determination of the drying shrinkage.

3). Thermal conductivity
Heat insulation is one of the most important properties of AAC products.
The insulation property of AAC is expressed by the coefficient of thermal conductivity, λ_{dry} (W/m*°K). The coefficient of thermal conductivity depends among other parameters decisively on the dry density of the product. Low density products have lower thermal conductivity hence good insulating properties.
The thermal conductivity is of major importance for the commercial image of the AAC products and the most important advantage of the AAC products relative to other building materials.
The thermal conductivity can be tested conform the indications of the European Standard EN 12664.

The thermal conductivity should be tested for the standard products about 4 times per year. In case of new products the thermal conductivity will be determined as a part of the suitability tests.

4. TESTS FOR THE CONTROL OF THE CASTING PROCESS

The most important parameters which should be measured at the moment the mass is discharged into the mould are:

4.1 Height of the AAC mixture immediately after discharging is finished

The level of the discharged AAC mass will be measured using a ruler or tape measure.

One end of the ruler will be positioned on the surface of the AAC mass. The height will be read on the edge of the mould.

4.2 Discharging temperature of the AAC mass

The temperature of the AAC mass will be measured while the discharging into the mould. It is recommendable to use an electronic thermometer with fast reaction time. Measuring range of the thermometer 0 – 300°C.

After the immersion of the thermo element into the AAC mass the temperature will increase quickly and after a short time the temperature will increase slowly. This is the actual temperature of the mass.

4.3 Discharging viscosity of the AAC mass

The viscosity of the AAC mass will be determined using:
1). a metal ring (interior diameter: 70 mm, height: 60 mm
2). a sheet of Acrylic-glass plate (400*400*5 mm)
3). a measuring beaker with handle (capacity: 500 ml)
4). a ruler (length: 500 mm).

The ring will be positioned in the middle of the Acrylic glass plate. While discharging AAC mass into the mould a sample is taken with the measuring beaker. The ring will be filled until the top edge with AAC mass poured from the beaker. As soon as the ring is full, it will be risen firmly from the plate and the AAC mass will spread. Two perpendicular diameters of the circular spot on the plate will be measured. The average of the two measuring will give the value of the “viscosity” expressed as “flow” in cm.

5. TESTS FOR THE CONTROL OF THE RISING/ STIFFENING PROCESS

After discharging into the mould due to the reaction of the components, the mass will expand until it reaches the gross volume of the mould. In the same time the temperature of the mixture will increase and its consistency will change. After a certain time the content of the mould will become a solid block, ready for cutting. Before removing the mould, the plasticity or green strength of the block will be checked using the penetrometer (part of the testing equipment).
This test is very important because it decides if the cake is ready for safe transportation and this operation can be done within the scheduled time. This is actually a basic condition for the designed operation of the factory.

The penetrometer indication, the temperature of the block (in 30 cm depth) and the time these tests were performed will be filled in form sheet.

In case of some special test, the evolution in time of the rising height and the temperature of the mass are registered. The evaluation of these curves gives a lot of useful information about the reaction in the mass, the stability of the casting and the measures necessary to improve the situation.

Instead of the penetrometer test to determine the evolution of the plasticity of the AAC cake, it can also be evaluated using a steel rod of determined size and mass. The rod will be dropped from 50 cm from the surface of the cake. It will penetrate into the cake to a certain depth. This depth expressed in cm indicates if the cake is ready to be cut.

Dimensions of the rod:

- Diameter: 10 mm
- Lenght: 400 mm

Mass of the rod: ca. 350 – 400g

Cutting can be started at an penetration depth of ca. 100 mm.

ANNEX 1

Recommended form sheets for the registration of testing results raw materials and products

Month /Year

Testing results of the compressive strength /Density class

Date	Density class	Number casting	Number recipe	Compressive Strength, N/mm²				Density at testing humidity g/cm³	Dry Density g/cm³	Testing humidity w%
				Compressive strength of the cubes, N/mm²						
				top	middle	bottom	Average compr. strength N/mm²			
01.xx.xx	500	01/0001		3,68	3,82	3,99	3,83	0,463	0,441	5,0
02.xx.xx	500	01/0002		3,57	3,63	4,02	3,74	0,453	0,430	5,3
03.xx.xx							0,00			#DIV/0!
04.xx.xx							0,00			#DIV/0!
05.xx.xx							0,00			#DIV/0!
06.xx.xx							0,00			#DIV/0!
07.xx.xx							0,00			#DIV/0!
08.xx.xx							0,00			#DIV/0!
09.xx.xx							0,00			#DIV/0!
10.xx.xx							0,00			#DIV/0!
11.xx.xx							0,00			#DIV/0!
12.xx.xx							0,00			#DIV/0!
13.xx.xx							0,00			#DIV/0!
14.xx.xx							0,00			#DIV/0!
15.xx.xx							0,00			#DIV/0!
16.xx.xx							0,00			#DIV/0!
17.xx.xx							0,00			#DIV/0!
18.xx.xx							0,00			#DIV/0!
19.xx.xx							0,00			#DIV/0!
20.xx.xx							0,00			#DIV/0!
21.xx.xx							0,00			#DIV/0!
22.xx.xx							0,00			#DIV/0!
23.xx.xx							0,00			#DIV/0!
24.xx.xx							0,00			#DIV/0!
25.xx.xx							0,00			#DIV/0!
26.xx.xx							0,00			#DIV/0!
27.xx.xx							0,00			#DIV/0!
28.xx.xx							0,00			#DIV/0!
29.xx.xx							0,00			#DIV/0!
30.xx.xx							0,00			#DIV/0!
31.xx.xx							0,00			#DIV/0!

Form sheet: dimensional accuracy

samplig		dimensions	length 1	length 2	aver. Length	width 1	width 2	aver. Width	height 1	height 2	aver. Height	flatness	plan parall.
date	place	mm*mm*mm	mm	mm	**mm**	mm	mm	**mm**	mm	mm	**mm**	mm	mm
dd.mm.yy	unloading	600*200*200	599,8	600,2	**600,0**	199,7	199,9	**199,8**	199,9	200,3	**200,1**	0,6	0,4
					-			-			-		
					-			-			-		
					-			-			-		
					-			-			-		
					-			-			-		
					-			-			-		
					-			-			-		
					-			-			-		

Form sheet – Lime analyses

Day of the month	Lime											
	slaking reactivity										passing on 90µm sieve	CaO_{total} content
	after 2 minutes	after 5 minutes	after 10 minutes	after 15 minutes	after 20 minutes	after 30 minutes	after 40 minutes	final temperature	minutes untilt 60°	tmax		
	°C	°C	°C	°C	°C	°C	°C	°C	min	min	M%	M%
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
Average												
Scatter												
rel. Scatter												
Minimum												
Maximum												
Number												

Form sheet - cement /gypsum analyses

Day of the month	Cement				Gypsum
	Setting of the cement			passing on 45 µm Sieve	LOI
	Begin	End	H_2O		
	minutes	minutes	M%	M%	M%
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
Average					
Scatter					
rel. Scatter					
Minimum					
Maximum					
Number					

Form sheet – slurry analyses

Day of the month	Slurries					
	sand slurry		ground sand sieve analysis			recirculated slurry
	pH-Value	Density	<90µm	<63µm	<45µm	Density
	-	kg/dm³	M%	M%	M%	kg/dm³
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
Average						
Scatter						
rel. Scatter						
Minimum						
Maximum						
Number						

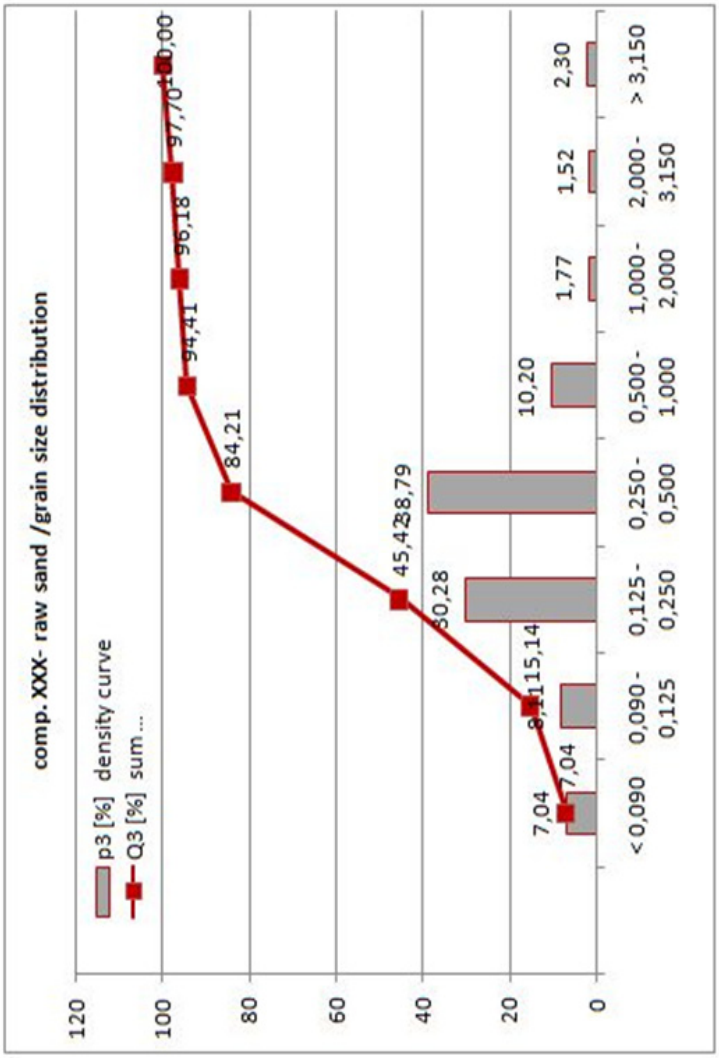
Form sheet – fly ash analyses

Day of the month	Fly ash		
	LOI	fraction < 45 µm	bulk density
	M%	M%	kg/dm³
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
Average			
Scatter			
rel. Scatter			
Minimum			
Maximum			
Number	0	0	0

Form sheet - sand analyses

Day of the month	Sand		
	Humidity	fraction < 63 µm	fraction <1mm
	M%	M%	M%
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
Average			
Scatter			
rel. Scatter			
Minimum			
Maximum			
Number			

Form sheet – grain size distribution sand



raw sand / comp XXX			
size classes [mm]	fraction weight,g	p3 [%] density curve	Q3 [%] sum distribution curve
< 0,090	21,04	7,04	7,04
0,090 - 0,125	24,23	8,11	15,14
0,125 - 0,250	90,51	30,28	45,42
0,250 - 0,500	115,94	38,79	84,21
0,500 - 1,000	30,49	10,20	94,41
1,000 - 2,000	5,29	1,77	96,18
2,000 - 3,150	4,53	1,52	97,70
> 3,150	6,89	2,30	100,00
Sum	298,92	100,00	

Density of sand slurry – correlations between solid content and water content

Density of sand slurry vs. solid content

Density of solid = 2,65 g/cm³

	1 liter slurry contains		1 kg slurry contains	
Dichte	kg Feststoff	kg Wasser	kg Feststoff	kg Wasser
1,25	0,402	0,848	0,321	0,679
1,26	0,418	0,842	0,331	0,669
1,27	0,434	0,836	0,341	0,659
1,28	0,450	0,830	0,351	0,649
1,29	0,466	0,824	0,361	0,639
1,30	0,482	0,818	0,371	0,629
1,31	0,498	0,812	0,380	0,620
1,32	0,514	0,806	0,389	0,611
1,33	0,530	0,800	0,398	0,602
1,34	0,546	0,794	0,408	0,592
1,35	0,562	0,788	0,416	0,584
1,36	0,578	0,782	0,425	0,575
1,37	0,594	0,776	0,434	0,566
1,38	0,610	0,770	0,442	0,558
1,39	0,626	0,764	0,451	0,549
1,40	0,642	0,758	0,459	0,541
1,41	0,658	0,752	0,467	0,533
1,42	0,675	0,745	0,475	0,525
1,43	0,691	0,739	0,483	0,517
1,44	0,707	0,733	0,491	0,509
1,45	0,723	0,727	0,498	0,502
1,46	0,739	0,721	0,506	0,494
1,47	0,755	0,715	0,514	0,486
1,48	0,771	0,709	0,521	0,479
1,49	0,787	0,703	0,528	0,472
1,50	0,803	0,697	0,535	0,465
1,51	0,819	0,691	0,542	0,458
1,52	0,835	0,685	0,549	0,451
1,53	0,851	0,679	0,556	0,444
1,54	0,867	0,673	0,563	0,437
1,55	0,883	0,667	0,570	0,430
1,56	0,899	0,661	0,577	0,423
1,57	0,915	0,655	0,583	0,417
1,58	0,932	0,648	0,590	0,410
1,59	0,948	0,642	0,596	0,404
1,60	0,964	0,636	0,602	0,398
1,61	0,980	0,630	0,609	0,391
1,62	0,996	0,624	0,615	0,385
1,63	1,012	0,618	0,621	0,379
1,64	1,028	0,612	0,627	0,373
1,65	1,044	0,606	0,633	0,367
1,66	1,060	0,600	0,639	0,361
1,67	1,076	0,594	0,644	0,356
1,68	1,092	0,588	0,650	0,350
1,69	1,108	0,582	0,656	0,344
1,70	1,124	0,576	0,661	0,339
1,71	1,140	0,570	0,667	0,333
1,72	1,156	0,564	0,672	0,328
1,73	1,172	0,558	0,678	0,322
1,74	1,188	0,552	0,683	0,317
1,75	1,205	0,545	0,688	0,312

a+b=p (a/2,65)+b=1 a = (r-1)/(1-(/(1/2.65)))

Density of flyash slurry – correlations between solid content and water content

Density of fly ash slurry vs. solid content

Density of solid = 2,30 g/cm³

	1 liter slurry contains		1 kg slurry contains	
Density	kg Solid	kg Water	kg Solid	kg Water
1,25	0,442	0,808	0,352	0,648
1,26	0,460	0,800	0,363	0,637
1,27	0,478	0,792	0,374	0,626
1,28	0,495	0,785	0,385	0,615
1,29	0,513	0,777	0,396	0,604
1,30	0,531	0,769	0,406	0,594
1,31	0,548	0,762	0,416	0,584
1,32	0,566	0,754	0,427	0,573
1,33	0,584	0,746	0,437	0,563
1,34	0,602	0,738	0,447	0,553
1,35	0,619	0,731	0,456	0,544
1,36	0,637	0,723	0,466	0,534
1,37	0,655	0,715	0,475	0,525
1,38	0,672	0,708	0,485	0,515
1,39	0,690	0,700	0,494	0,506
1,40	0,708	0,692	0,503	0,497
1,41	0,725	0,685	0,512	0,488
1,42	0,743	0,677	0,521	0,479
1,43	0,761	0,669	0,529	0,471
1,44	0,778	0,662	0,538	0,462
1,45	0,796	0,654	0,546	0,454
1,46	0,814	0,646	0,555	0,445
1,47	0,832	0,638	0,563	0,437
1,48	0,849	0,631	0,571	0,429
1,49	0,867	0,623	0,579	0,421
1,50	0,885	0,615	0,587	0,413
1,51	0,902	0,608	0,594	0,406
1,52	0,920	0,600	0,602	0,398
1,53	0,938	0,592	0,610	0,390
1,54	0,955	0,585	0,617	0,383
1,55	0,973	0,577	0,625	0,375
1,56	0,991	0,569	0,632	0,368
1,57	1,008	0,562	0,639	0,361
1,58	1,026	0,554	0,646	0,354
1,59	1,044	0,546	0,653	0,347
1,60	1,062	0,538	0,660	0,340
1,61	1,079	0,531	0,667	0,333
1,62	1,097	0,523	0,674	0,326
1,63	1,115	0,515	0,680	0,320
1,64	1,132	0,508	0,687	0,313
1,65	1,150	0,500	0,693	0,307
1,66	1,168	0,492	0,700	0,300
1,67	1,185	0,485	0,706	0,294
1,68	1,203	0,477	0,712	0,288
1,69	1,221	0,469	0,719	0,281
1,70	1,238	0,462	0,725	0,275
1,71	1,256	0,454	0,731	0,269
1,72	1,274	0,446	0,737	0,263
1,73	1,292	0,438	0,743	0,257
1,74	1,309	0,431	0,749	0,251
1,75	1,327	0,423	0,754	0,246

a+b=p (a/2,30)+b=1 a = (r-1)/r *(2,30/(2.30-1))

Density of recirculated slurry – correlations between solid content and water content

Density of recirculated slurry vs. solid content

Density of solid= 2,55 g/cm³

	1 Liter slurry contains		1kg slurry contains	
Density of recirculates slurry	kg solid	kg water	kg solid	kg water
1,25	0,411	0,839	0,329	0,671
1,26	0,428	0,832	0,339	0,661
1,27	0,444	0,826	0,350	0,650
1,28	0,461	0,819	0,360	0,640
1,29	0,477	0,813	0,370	0,630
1,30	0,494	0,806	0,380	0,620
1,31	0,510	0,800	0,389	0,611
1,32	0,526	0,794	0,399	0,601
1,33	0,543	0,787	0,408	0,592
1,34	0,559	0,781	0,417	0,583
1,35	0,576	0,774	0,427	0,573
1,36	0,592	0,768	0,435	0,565
1,37	0,609	0,761	0,444	0,556
1,38	0,625	0,755	0,453	0,547
1,39	0,642	0,748	0,462	0,538
1,40	0,658	0,742	0,470	0,530
1,41	0,675	0,735	0,478	0,522
1,42	0,691	0,729	0,487	0,513
1,43	0,707	0,723	0,495	0,505
1,44	0,724	0,716	0,503	0,497
1,45	0,740	0,710	0,511	0,489
1,46	0,757	0,703	0,518	0,482
1,47	0,773	0,697	0,526	0,474
1,48	0,790	0,690	0,534	0,466
1,49	0,806	0,684	0,541	0,459
1,50	0,823	0,677	0,548.	0,452
1,51	0,839	0,671	0,556	0,444
1,52	0,855	0,665	0,563	0,437
1,53	0,872	0,658	0,570	0,430
1,54	0,888	0,652	0,577	0,423
1,55	0,905	0,645	0,584	0,416
1,56	0,921	0,639	0,591	0,409
1,57	0,938	0,632	0,597	0,403
1,58	0,954	0,626	0,604	0,396
1,59	0,971	0,619	0,610	0,390
1,60	0,987	0,613	0,617	0,383
1,61	1,004	0,606	0,623	0,377
1,62	1,020	0,600	0,630	0,370
1,63	1,036	0,594	0,636	0,364
1,64	1,053	0,587	0,642	0,358
1,65	1,069	0,581	0,648	0,352
1,66	1,086	0,574	0,654	0,346
1,67	1,102	0,568	0,660	0,340
1,68	1,119	0,561	0,666	0,334
1,69	1,135	0,555	0,672	0,328
1,70	1,152	0,548	0,677	0,323
1,71	1,168	0,542	0,683	0,317
1,72	1,185	0,535	0,689	0,311
1,73	1,201	0,529	0,694	0,306
1,74	1,217	0,523	0,700	0,300
1,75	1,234	0,516	0,705	0,295
a+b=p	(a/2,65)+b=1	a = (r-1)/(1-(1(112.65)))		

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