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Monolithic (unshaped) refractory products —

Part 4: Determination of consistency of castables

Produits réfractaires monolithiques (non façonnés) —

Partie 4: Détermination de la consistance des bétons

Reference number
ISO 1927-4:2012(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 1927-4 was prepared by Technical Committee ISO/TC 33, *Refractories*.

ISO 1927 consists of the following parts, under the general title *Monolithic (unshaped) refractory products*:

— *Part 1: Introduction and classification*

— *Part 2: Sampling for testing*

— *Part 3: Characterization as received*

— *Part 4: Determination of consistency of castables*

— *Part 5: Preparation and treatment of test pieces*

— *Part 6: Measurement of physical properties*

— *Part 7: Tests on pre-formed shapes*

— *Part 8: Determination of complementary properties*

Monolithic (unshaped) refractory products —

Part 4:
Determination of consistency of castables

1 Scope

This part of ISO 1927 describes methods for the determination and measurement of the consistency of dense and insulating castables as defined in ISO 1927-1. It is applicable to all types of dense regular castables, dense deflocculated castables and insulating castables to determine the liquid addition necessary for preparing test pieces according to ISO 1927-5.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1927-1, *Monolithic* (*unshaped) refractory products — Part 1: Introduction and classification*

ISO 1927-5:2012, *Monolithic* (*unshaped) refractory products — Part 5: Preparation and treatment of test pieces*

3 Principle

The amount of water used in a castable mix for preparing test pieces has a significant influence on the test results. Excess water can reduce strength, increase shrinkage, and can cause sedimentation. Insufficient moisture can give voids due to poor compaction, with subsequent lower density and strength.

This part of ISO 1927 describes three different methods for determining the consistency according to the type of material:

a) determination of the consistency of insulating castables containing significant amounts of light-weight aggregates such as vermiculite or perlite which would be destroyed by intensive mixing; such products are normally installed by pouring, rodding, tamping;

b) determination of the consistency of all types of vibratable castables;

c) determination of the consistency of self-flowing castables.

To obtain reproducible results, the following factors are closely controlled:

— wet mixing time;

— batch size, which is chosen for the required number of determinations (e.g. if determination of working time is required), and is also related to mixer pan size or bowl;

— mixer pan size adapted to batch weight to have at least 50 % and a maximum of 75 % volume loading by the dry batch;

— temperature (of the water, castable and mix and ambient temperature), of 18 °C to 22 °C for consistency and working time determination;

— quantity of water addition used in the test which is rapidly affected when the dry volume loading of the mixer pan drops below 50 % of the total dry capacity, due to the increased metal surface to be wetted;

— water quality.

4 Apparatus

4.1 Mixer, conforming to the requirements of 4.2 of ISO 1927-5:2012.

4.2 Vibrating table, conforming to the requirements of 4.3 of ISO 1927-5:2012.

4.3 Trowel, conforming to the requirements of 4.7 of ISO 1927-5:2012.

4.4 Metal moulds (see Figures 1 and 2), comprising two truncated cones, with a diameter of 100 mm at the bottom, and 70 mm at the top.

One cone shall be 50 mm in height and the other shall be 80 mm in height.

The moulds should preferably be made from stainless steel with chromium-plated inside surfaces.

Dimensions in millimetres

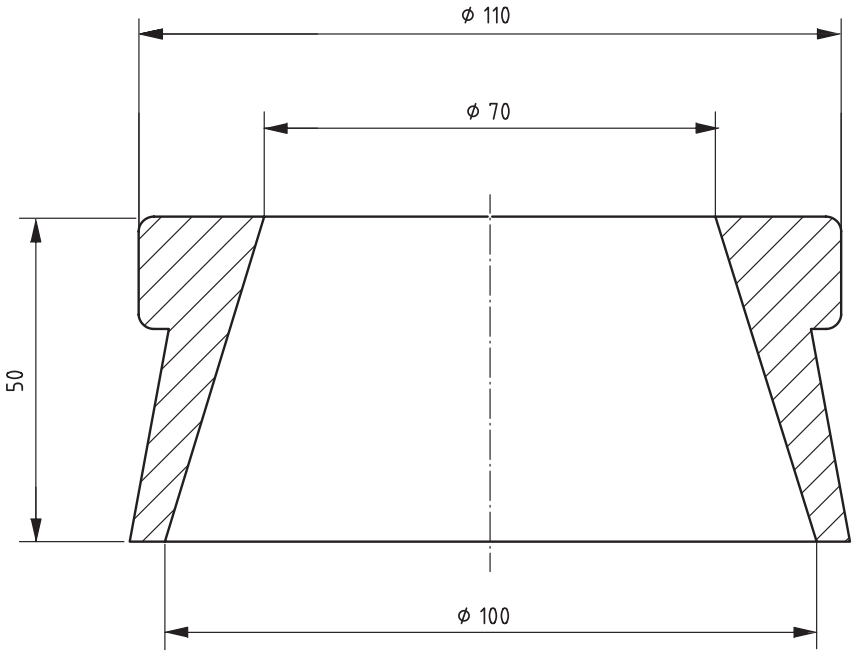


Figure 1 — Cone 1, of height 50 mm

Dimensions in millimetres

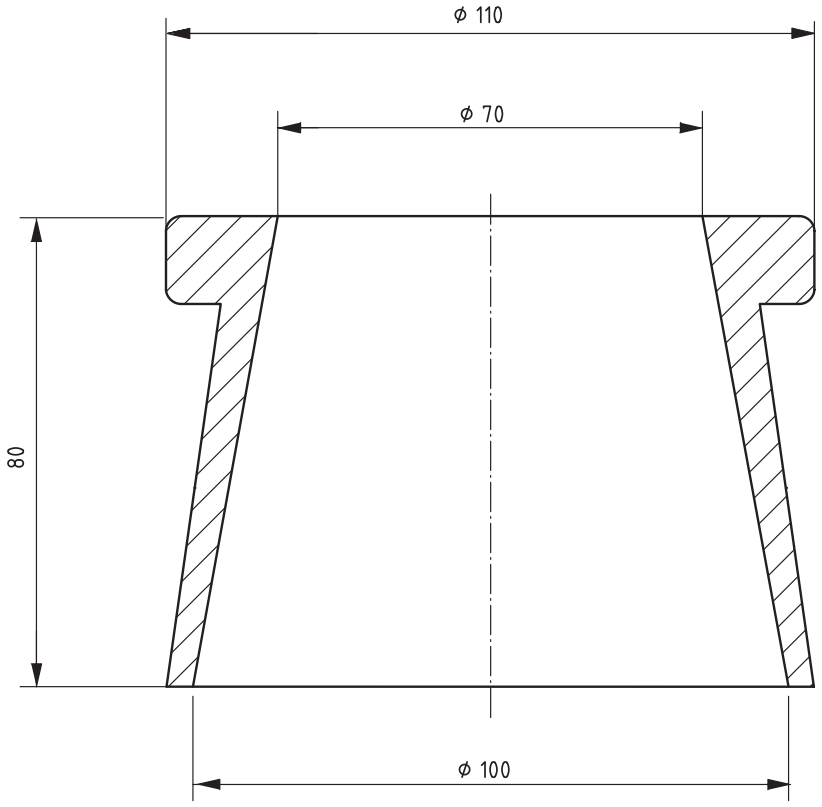


Figure 2 — Cone 2, of height 80 mm

4.5 Metal bowl, suitable for manual mixing of a test batch of correct size.

NOTE For example a diameter of 450 mm and a depth of 150 mm is suitable for many products.

4.6 Two balances, one capable of weighing up to 25 kg with an accuracy of ± 50 g, and the other capable of weighing up to 5 kg with an accuracy of ± 1 g.

4.7 Stop-watch.

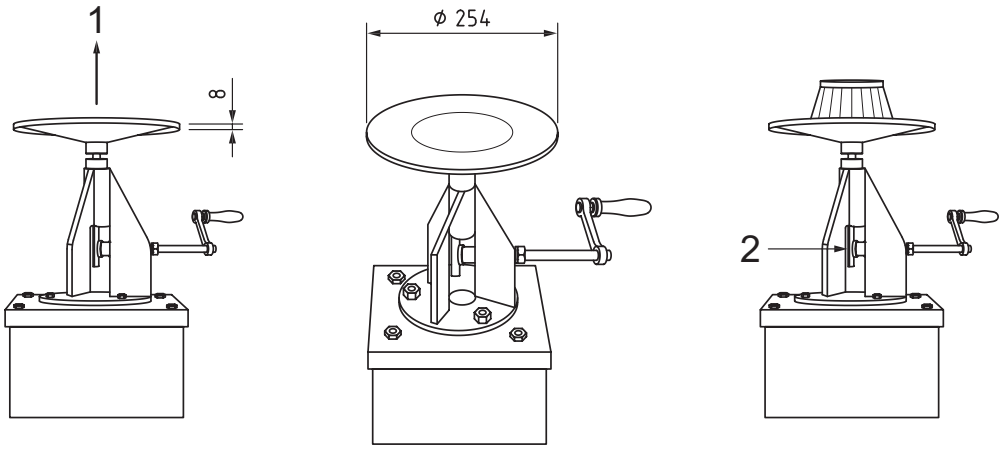
4.8 Callipers.

4.9 Thermometer, for measuring the temperature of the water, material and mix.

4.10 Water, pure mains water of recognized drinking quality.

4.11 Tapflow table, as shown in Figure 3, where the crank is rotated to give a circular movement to the turntable ands the cam lifts the turntable through 8 mm.

Dimensions in millimetres



Key

1 3845*g*

2 Course 8 mm

Figure 3 — The tap flow table

5 Procedure

5.1 Determination of the consistency of insulating castables for rodding and tamping

5.1.1 Weigh sufficient material to ensure filling 50 % to 60 % of the bowl volume of the dry sampled castable to the nearest 1 g and place it in the metal bowl (see 4.5) for manual mixing (see 5.2.1.2 of ISO 1927-5:2012) or low-intensity mechanical mixing (see 5.2.1.3 of ISO 1927-5:2012).

Place a known mass of water, at least twice as great as that of the castable sample, in a separate container with a pouring lip. If the manufacturer recommends a minimum quantity of water to be added, use an initial water addition of 75 % of this quantity, again weighed to the nearest 1 g. Where no recommendation is given, add a quantity of water just sufficient to wet the castable thoroughly, again weighed to the nearest 1 g. The temperature of the water and the castable shall be between 18 °C and 22 °C.

5.1.2 Mix this water manually or in the low-intensity mixer with the castable until it is evenly dispersed. Make successive further small additions of water from a calibrated container, mixing with each addition until the mix begins to form a coherent mass. At this stage, reduce the water increments to a maximum of 1 % of the castable sample.

5.1.3 After each of these additions, knock the bowl on a hard surface six times. A mix of the correct consistency should flow easily and form a shiny wet surface. If necessary, add water until this consistency is reached. Weigh the remaining water in the container and calculate the water addition made to the castable as a percentage of the dry castable mass. Record this percentage.

5.1.4 Leave the bowl for 5 min and again knock it six times on a hard surface to check the consistency. If necessary, add small amounts of water to obtain the correct consistency, in which case the total amount of water added shall be reported. Do not allow the total time taken to achieve the correct consistency to exceed 20 min from the first addition of water.

NOTE After the mix has been left in the bowl for 5 min it may be necessary to mix again, before making further water additions.

5.1.5 Record the amount of water required for the correct consistency, expressed in litres of water per hundred kilogrammes (l/100 kg) of dry castable.

5.2 Determination of the consistency of castables by tap flow table method

5.2.1 Weigh a sufficient quantity of the sampled castable to obtain at least 50 % (preferably 75 %) volume loading of the mixer pan by the dry batch. Place this weighed amount in the mixer pan (see 4.1).

In the case of a multi-component material, weigh the equivalent amounts of each component and place them in the mixer pan. A separate dry mixing time of 1 min is necessary.

5.2.2 Switch on the mixer, start the stop-watch (see 4.7) and add, within 30 s, the average amount of water within the range recommended by the manufacturer.

NOTE 1 The wet mixing time should not be less than 2 min nor exceed 8 min, depending on the product type or the time recommended by the manufacturer.

NOTE 2 Generally, deflocculated castables require a longer mixing time than regular castables and a wet mixing time of 4 min may be necessary to avoid overwatering.

5.2.3 Position the lightly oiled tapered mould of suitable height (see 4.4), normally 50 mm, to the top surface of the flow table with its larger diameter (100 mm) facing downwards.

NOTE The 80 mm cone should be used for castables with a maximum grain size greater than 6,3 mm

5.2.4 Place the mixed castable in the mould so that it forms a small heap above the top surface or rim of the mould and strike off the surface level with the top of the mould within a maximum time of 30 s.

5.2.5 Carefully lift off the mould from the table, leaving the castable in place.

5.2.6 Action the tap flow table with the crank such that one tap is given to the table. Repeat 14 times, with one rotation per second.

5.2.7 Measure the two diameters at right angles d_1 and d_2 of the flattened sample using callipers and calculate the slump value S_v as:

$$S_v = (d_1 + d_2)^2$$

Record the mean value of both measurements to the nearest millimetre and record this as the slump value S_v.

Record the amount of water required for the measured consistency (S_v) and calculate as a ratio of the used mass of dry material, expressed in litres of water per hundred kilograms (l/100 kg) of dry castable.

5.2.8 If the consistency value is not in the range specified by the manufacturer, or that expected from previous experience, repeat the test from 5.2.1 to 5.2.7, adjusting the quantity of water to obtain the desired consistency.

NOTE If the flow value is judged to be satisfactory, steps 5.2.3 to 5.2.7 can be repeated with a new increment from the same wet mixed batch at intervals of approximately 15 min to 20 min in order to measure the working time. In this case, it may be necessary to increase the quantity of castable used for the test (see 5.2.1).

5.3 Determination of the consistency of dense vibrating castables by cone vibration method

5.3.1 Weigh a sufficient quantity of the sampled castable to obtain at least 50 % (preferably 75 %) volume loading of the mixer pan by the dry batch. Place this weighed amount in the mixer pan (see 4.1).

5.3.2 In the case of a multi-component material, weigh the equivalent amounts of each component and place them in the mixer pan. A separate dry mixing time of 1 min is necessary.

5.3.3 Switch on the mixer, start the stop-watch (see 4.7) and add, within 30 s, the average amount of water within the range recommended by the manufacturer.

NOTE 1 The wet mixing time should not be less than 2 min nor exceed 8 min, depending on the product type or the time recommended by the manufacturer.

NOTE 2 Generally, deflocculated castables require a longer mixing time than regular castables and a wet mixing time of 4 min may be necessary to avoid overwatering.

5.3.4 Fix the lightly oiled tapered mould of suitable height (see 4.4) to the top surface of the vibrating table with its larger diameter (100 mm) facing downwards.

NOTE The 80 mm high cone should be used for products with a grain size greater than 6,3 mm

5.3.5 Place the mixed castable into the mould so that it forms a small heap above the top surface or rim of the mould within a maximum time of 30 s.

5.3.6 Switch on the vibrating table (see 4.2) with a preset amplitude of 0,50 mm for all castables. Add more castable as required so that the mould is slightly overfilled. Scrape off the excess castable with the trowel, and remove it. Remove any material which has dropped on to the table top. Stop the vibration after 30 s.

NOTE The table surface can be slightly oiled.

5.3.7 Lift the mould vertically from the table, lightly pressing down the castable sample so that minimal deformation of the test piece occurs. Switch on the vibrating table at the same appropriate amplitude (see 5.2.6) with the sample in place for 20 s. Stop the vibration. Record the time elapsed from the start of water addition (see 5.2.2).

5.3.8 Measure two diameters of the flattened sample at right angles to each other using callipers (see 4.8). Record the mean value of both measurements, $\bar{d}$, to the nearest millimetre.

5.3.9 The consistency is defined as a flow value, F_V, which is the ratio of the change in the average diameter, in millimetres, to the original lower diameter of the mould, expressed as a percentage.

Calculate the flow value, F_V in %, using the equation:

$$F_{\mathrm{V}} = \left(\frac{\bar{d} - d_{\mathrm{o}}}{d_{\mathrm{o}}} \right) \times 100$$

where

$\bar{d}$ is the mean diameter of the flattened sample (see 5.2.7);

d_0 is the original lower diameter, i.e. 100 mm.

5.3.10 Record the amount of water required for the measured consistency (F_V) and calculate as a ratio of the used mass of dry material, expressed in litres of water per hundred kilograms (l/100 kg) of dry castable.

5.3.11 If the consistency value is not in the range specified by the manufacturer, or that expected from previous experience, repeat the test from 5.2.1 to 5.2.7, adjusting the quantity of water to obtain the desired consistency.

NOTE If the flow value is judged to be satisfactory, steps 5.2.4 to 5.2.7 can be repeated with a new increment from the same batch at intervals of approximately 15 min to 20 min in order to measure the working time. In this case, it may be necessary to increase the quantity of castable used for the test (see 5.2.1).

5.4 Determination of the consistency of self-flowing castables

5.4.1 Follow the mixing procedure in 5.3.1 to 5.3.3.

5.4.2 In order to measure the consistency of self-flowing castables, allow the wet mixed material to spread out horizontally under its own weight.

5.4.3 Hold the lightly oiled mould of 80 mm height firmly on a vibration-free table or steel plate, at a convenient working height, with its larger diameter (100 mm) facing downwards.

NOTE The table surface can be slightly oiled .

5.4.4 Pour the wet mixed castable immediately into the mould until level with the top surface. Wait 15 s, adding more material if required to fill the mould. Using the trowel, level off the castable with the top of the mould removing any excess material from the mould or around the base.

5.4.5 Lift the mould vertically from the table and let the castable flow freely for 2 min.

5.4.6 Using callipers (see 4.8), measure two diameters of the flattened sample at right angles to each other. Record the mean value of both measurements, $\bar{d}$, to the nearest millimetre. Record the time elapsed from the start of water addition (see 5.2.2).

5.4.7 The consistency is defined as the flow value, F_V, which is the ratio of the change in the average diameter, in millimetres, to the original lower diameter (d_0 = 100 mm) of the mould, expressed as a percentage:

Calculate the flow value, F_V in %, using the equation:

$$F_v = \left(\frac{\bar{d} - d_0}{d_0} \right) \times 100$$

where

$\bar{d}$ is the mean diameter of the flattened sample (see 5.2.7);

d_0 is the original lower diameter, i.e. 100 mm.

5.4.8 Record the amount of water required for the measured consistency (F_V) and calculate as a ratio of the used mass of dry material, expressed in litres of water per hundred kilograms (l/100 kg) of dry castable.

5.4.9 If the consistency value is not in the range specified by the manufacturer, or that expected from previous experience, repeat the test from 5.4.2 to 5.4.8, adjusting the quantity of water to obtain the desired consistency.

NOTE If the flow value is judged to be satisfactory, steps 5.4.3 to 5.4.8 can be repeated with a new increment from the same batch at intervals of approximately 15 min to 20 min in order to measure the working time. In this case, it may be necessary to increase the quantity of castable used for the test (see 5.3.1).

6 Test report

The test report shall include the following information:

a) all information necessary for identification of the sample tested including batch number, production date and the designation of the product tested, in accordance with ISO 1927-1;

b) a reference to this International Standard, i.e. ISO 1927-4:2012;

c) the results of the tests, including the results of the individual determinations and their mean:

   1) for insulating castables:

      i) the amount of water used in the test, expressed as litres per hundred kilograms (l/100 kg) of dry material;

ii) the total time for the measurement after the first water addition;

iii) the mixing method, manual or low-intensity mechanical

2) for vibratable castables and self-flowing castables:

i) the flow values obtained with the corresponding amounts of added water, expressed as litres per hundred kilograms;

ii) the time elapsed after the first addition of water for each flow value measured;

iii) the height of the cone used in the test;

iv) the wet mixing time.

d) any deviations from the procedure specified;

e) any unusual features (anomalies) observed during the test;

f) the name of the test laboratory including the place of the test, the report identification and signatory;

g) the date of the test.

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