Indian Standard

METHODS OF PHYSICAL TESTS FOR FOUNDRY SANDS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 8 August 1966, after the Structural and Metals Division Council had approved the draft finalized by the Foundry Sectional Committee.

0.2 This standard outlines basic principles of physical tests for foundry sands. Standard sand testing equipment shall be used for testing foundry sands. Detailed precautions supplied by the manufacturer with the testing equipment shall be followed along with the procedures specified in this standard. The test specimen to be used shall be one of the two recommended in this standard as applicable to the equipment.

0.3 This standard keeps in view the manufacturing and trade practices followed in the country in this field. While preparing this standard, assistance has been derived from the following:

> DIN 52401 Examination of clay free and clay bonded moulding sands in the loose and the compressed moist and green state. Deutscher Normenausschuss.
>
> Foundry sand handbook. 1963. Ed 7. American Foundrymen’s Society, Illinois, USA.

0.4 To decide whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off by following IS: 2-1960*. The number of significant places retained- in the rounded-off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard prescribes the methods of tests for foundry sands to evaluate their properties under standard conditions.

SECTION 1 GENERAL

2. TERMINOLOGY

2.1 For this standard, the term ‘Foundry Moulding Sand’ shall include high-silica sand, natural moulding sand, synthetic moulding sand mixtures, and reclaimed sand placed in heaps on the foundry floor for reuse.

2.2 The term ‘Core Sand’ shall cover sand that is suitable for making cores, usually low in clay substance.

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*Rules for rounding off numerical values (*revised*).

3. SAMPLING

3.1 Representative samples shall be drawn according to the scheme of sampling given in IS: 1811-1961*.

4. PREPARATION OF FOUNDRY SAND FOR TESTING

4.1 Preparation of High-Silica Sand — The samples in accordance with 3.1 shall be used without any processing.

4.2 Preparation of Natural Moulding Sand

4.2.1 *Tempering by Hand* — Dry about 2-kg sample of sand for one hour at ~~105~~100° to 110°C. Spread the sand over a large area in a thin layer so that all moisture is expelled in the given time. Collect the sample sand in a plastic bag or container of suitable size to avoid exposure to ambient moisture/ humidity. After allowing the sand to cool down to room temperature, measure the quantity of water needed to give the desired moisture content (in terms of per cent weight of tempered mix), adding little extra water (usually from ~~O 25 to 1 O~~ 0.25 to 1 per cent) to allow for evaporation. Spread the sand on a smooth, flat, dry, non-absorbent surface in a layer about 25 mm thick. Sprinkle a small quantity of the water from the measured quantity evenly over the sand and work the sand gradually. Spread again the sand into a thin layer and repeat the above operations, adding more water. Repeat the process until all the water has been thoroughly distributed in the sand. There should be no dry lumps or other evidence of uneven tempering.

4.2.2 *Alternate Method of Tempering by Hand* — In case sand has a lower moisture content than desired, it need not be dried before tempering. Add sufficient water to bring the sand to the desired moisture content. In case the sand has a higher moisture content than desired, the sand shall be partially dried, allowed to cool and then tempered with sufficient water to bring the moisture to the desired value.

4.2.3 *Tempering by Mechanical Mixing* — Dry about 2-kg sample of sand as given in **4.2.1**. Place the dried sand in the ~~l~~Laboratory ~~m~~Mixer or Muller and add sufficient water to produce the desired moisture content plus an additional amount to allow for evaporation during mixing. Water should be added gradually within 30 seconds while the mixer is operating. Total mixing time should be 5 minutes.

> NOTE - Any one method of tempering shall be followed throughout to prepare sand mixture of same or different moisture contents during the course of an investigation for evaluating a sand sample.

4.3 *Preparation of Synthetically Bonded Sand Mixture* — Test samples of synthetically bonded sand mixture shall be prepared in a mechanical mixer. Dry about 2 kg of sand for one hour at 105° to 110°C. Spread the sand over a large area in a thin layer so that all moisture is expelled in the given time. After drying and cooling to room temperature, weigh the correct amounts of sand or sands, and bond or bonds, as used in the foundry mixtures. Place the dried sand and then the dried bonding materials, in the mixer. Place the cover on the mixer, start the mixer and mix for two minutes. Following the two-minute mixing period, allow two minutes for dust to settle before removing the mixer cover. Add the required amount of water gradually within 30 seconds to give the required moisture percentage plus sufficient additional water to allow for evaporation during mixing.

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*Methods of sampling foundry sands.

Mix for ~~a period of~~ 5 minutes. Remove the sand from the mixer as quickly as possible. Allow samples to stand in an air-tight container for two hours before testing.

> NOTE - Variation in physical properties with moisture content shall be determined by giving small increments to water content (say 0.5 to 1.0 per cent).

5. PREPARATION OF STANDARD TEST SPECIMEN

5.1 Apparatus — Standard sand rammer with accessories as per IS 10487:1983 or Sand Squeezer~~.~~

5.2 Test Specimen — Cylindrical test specimen of 50.8 ± 0.~~0~~3 mm height and 50.8 ± 0.3 mm diameter (or of 50 ± 0.3 mm height and 50 ± 0.3 mm diameter) shall be used.

5.3 Procedure — Weigh a sufficient quantity of tempered sand mixture to make~~, when rammed,~~ a rammed specimen of the required height. ~~Place~~ Pour the sand carefully in the specimen ~~container~~tube through a riddling sieve using a Tube filler accessory. ~~After~~ ~~l~~Level~~ling~~ the sand in the ~~container~~ specimen tube.~~,~~ If using a sand rammer to prepare standard specimen, gently lower the ramming head into the specimen container, until it is supported by the sand. Slowly raise the rammer weight by hand or by cam to the full height of the specimen and let it fall. a total of 3 rams to get the standard test specimen. A sand squeezer should typically make the specimen in one squeeze.

5.3.1 For sands which do not possess sufficient bond strength to permit handling, a circular drier plate shall be placed on top of a stripping post. After the specimen is stripped from the container, it shall be handled by lifting the drier plate.

5.3.2 For preparing specimens of low bond strength or specimens which tend to stick to specimen tube, ramming is done in a split specimen tube. The specimen, after it is rammed, is removed from the split specimen tube by opening the tube and allowing the specimen to rest on a drier plate.'

SECTION 2 METHOD OF PHYSICAL TESTS FOR FOUNDRY MOULDING SANDS

6. DETERMINATION OF MOISTURE CONTENT

6.1 Direct Weigh~~t~~ Method*

6.1.1 *Procedure* — Weigh accurately about 100 g of~~cf~~ sample of sand in a ~~tared~~ covered porcelain dish. Dry it in a uniformly heated oven between 100~~5~~º and 110º C for about one hour~~. Cool to room temperature and weigh. Repeat the process of drying and cooling till constant weight is attained.~~ Check the weight of the sample every 5 minutes and stop drying when stable weight is observed.

6.1.2 Calculate the percentage moisture by the following formula:

$$\text{Moisture, percent} = \frac{A}{B} \times 100$$

Where

A = loss of weight of the sand sample in g on heating, and
B = weight in g of the sand sample taken.

6.1.3 Make the determination on three separate samples and take the average of three test results as the moisture content of the sand.

6.2 Calcium Carbide Method

6.2.1 *Apparatus* — Speedy Moisture Tester.

6.2.2 *Procedure* — Weigh accurately about 6 g of sample of sand and place it in the cap of the instrument. Take a measure of calcium carbide and place in the shaker. Place the cap and the shaker in the horizontal position, adjust stirrup, fasten cap to shaker with set screw on stirrup and finally shake the contents. Read moisture content on dial gauge keeping the apparatus in a horizontal position. Make determinations on three separate samples and take the average of three results as the moisture content of the sand mixture.

> **NOTE** — The sand mixture and calcium carbide should not come in contact with each other until the cap of the moisture tester is securely in place. Before the Test is conducted, the activity of Calcium carbide needs to be verified by taking about 1 g of Calcium carbide and observing its violent reaction with drops of water.

6.3 Control Methods — For control tests, moisture in foundry sands may be determined by direct weight method, calcium carbide method or by any other method (such as dielectric or multimodal -type moisture meters) which will duplicate the accuracy of results obtained by the direct weight method. For comparison of results obtained by different methods, time after which result is obtained after sampling must be constant.

7.1 Apparatus — An electric rapid agitator equipped with vertical baffles or a rotating sand washer shall be used

7.2 Reagent

7.2.1 *Sodium Hydroxide Solution* — Dissolve 30 g of sodium hydroxide in distilled water and dilute to a total volume of one litre.

7.3 Procedure

7.3.1 *General* — Take a 50-g representative sand sample. Spread it over a large area in thin layer and dry it for one hour at 100° to 110°C so that all moisture is expelled. Weigh the

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*This method is applicable for all sand mixtures except those containing volatile material (other than water) or oxidizable materials such as core oils or both. For such sand mixture, calcium carbide method (*see* **6.2**) shall be used.

dried sample and place it in an elect rapid agitator equipped with vertical baffles or a rotating sand washer. Add 475 ml of distilled water (@H 7.0 deionized or demineralized water) &d 25 ml of sodium hydroxide solution at room temperature. Stir for five minutes. (If a rotating washer is used, place the cover on the jar, and the jar in a machine making about 60 rev/min in such a manner as to allow the jar to be opened at each revolution. Operate the machine for one hour. Then remove the jar from the machine, unseal the cover and wash the adhering sand into the jar,) Wash sand from the stirrer into the jar and fill the jar with distilled water to a height of 150 mm above the bottom of the jar and in such a manner that the contents are well stirred. Allow to settle for 10 minutes and then syphon off the water to a depth of exactly 125 mm below the level to which it had been filled, leaving a minimum depth of 25 mm of water in the bottom of the jar. Add distilled water, again filling the jar to the 150 mm height, stirring the sediment at the bottom. After settling for the second time for 10 minutes, again siphon off 125 mm of the water. Add water again filling to 150 mm height, stirring the sediment at the bottom. After settling exactly for 5 minutes, siphon off 125 mm of the water. Repeat the process of five minutes standing and siphoning until the water is clear to a depth of 25 mm at the en of five-minute period. By this method, the material which fails to settle at a rate of 25 mm per minute is removed. This is standard clay grade matter and includes all grains of 20 microns or ‘less in diameter. Dry and weigh the remaining grains. The difference between the weight of the dried grains and that of the original 50-g sample represents clay content.

NOTE - Certain varieties of sand may ~~rewire~~ require longer agitation to liberate properly the clay from the sand grains. Incomplete clay removal may be checked microscopically.

7.3.1.1 Calculate clay content and sand portion by the following formulae: -

$$\text{Clay content, percent} = \frac{W_1 - W_2}{W_1} \times 100$$

$$\text{Sand portion, percent} = \frac{W_2}{W1} \times 100$$

where

W_1 = weight in g of the dried sand sample taken for the ~~test~~Test, and
W_2 = weight in g of the dried sand portion (free from clay).

7.3.2 *Synthetic Sand Mixture* — The procedure in accordance with **7.3.1** hall be slightly changed for sand mixtures containing coal dust, coal residues, and binder residues. As given in 7.3.1, 50 g of foundry sand is washed after drying. In the course of washing operations, a part of the coal dust and similar substances is removed, the remainder being part of the sand portion. The washed sand portion is heated in a porcelain crucible to 750°C for burning the coal and the coal-free sand is weighed. The heating loss, equal to the total coal content, is determined by heating to 750°C and weighing a separate sample of unwashed, dried foundry sand. The heating time should be sufficient for the complete combustion of the coal contained in the sand. The clay substance shall be the difference between the true sand portion (washed and heated sample) plus coal portion (of unwashed and heated sample), and the total quantity of unwashed dried sand.

7.3.2.1 If cereal binders (especially dextrin) are present in the sand, a preliminary wash shall be made without adding sodium hydroxide to the distilled water. After stirring and allowing the sand to settle for 10 minutes, siphon off the water. Then proceed as under **7.3.1**.

7.3.2.2 A sand mixture containing cement cannot be washed free of cement by the method given under **7.3.1**. The cement shall be removed from the sand grains by adding 25 ml of dilute hydrochloric acid (1:1 by volume) instead of sodium hydroxide, taking suitable precautions against acid attacking the agitating apparatus.

8. DETERMINATION OF GRAIN FINENESS

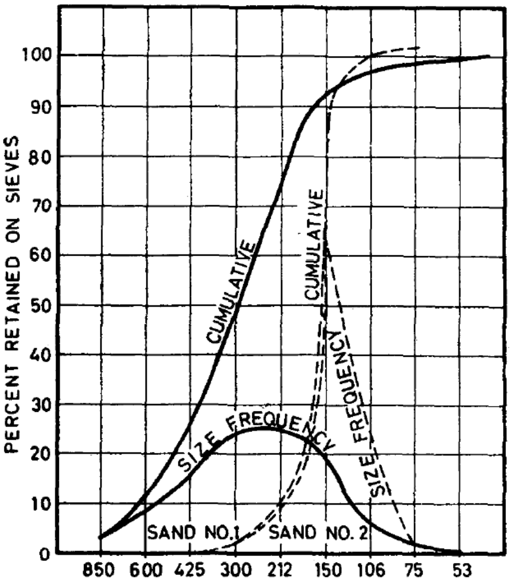
8.1 General —The percentage of grain sizes shall be determined by sieving -the dried clay-free sand. Sifting time shall be at least 15 minutes and the test sieves used shall be 3.35-mm, l.70-mm, 850-micron, 600-micron, 425-micron, 300-micron, 212-micron, 150-micron, 106-micron, 75-micron and 53-micron IS Sieves.

8.2 Apparatus — A set of Indian Standards Sieves (*see* IS: 460-~~1962*~~Part 1* or ISO3310-1 or ASTM E11).

8.3 Procedure — Sieve 50-g of representative sample through 11 sieves indicated under **8.1** starting with the coarse sieve. Weigh out the sand retained on each sieve and the pan material individually and put down as percent of the dried unwashed sand.

8.4 Evaluation of Fineness of Sand

8.4.1 *Size-Frequency Curve* — The size-frequency curve shall be obtained by plotting the percent of sand retained on each sieve (*see* **Fig. 1**).



IS SIEVE DESIGNATIONS IN MICRONS

NOTE- Values along abscissa are plotted on log scale.

FIG. 1 CURVES CONSTRUCTED FROM SIEVE ANALYSIS OF TWO FOUNDRY SANDS TO SHOW COMPARISON OF SIZE-FREQUENCY AND CUMULATIVE CURVES

8.4.2 *Cumulative Curve* — The cumulative curve points shall indicate the percentage of particles larger than the sieve size represented by that point (*see* **Fig. 1**). The cumulative curve is always smooth, whereas size frequency curve may not always be a broken line connecting the different sieve points. If a sand is taken on specification, two cumulative curves may be drawn showing the limiting values for each sieve. Then, if the curve of the sand being tested falls between these two curves it shall be satisfactory. Finally, data for slit and clay may be plotted as a part of the same graph. Sieves that retain little material may be eliminated or additional ones may be added without distorting the curve. If there are faulty sieves these shall be indicated by a break at the same point in the curve when different samples of the same sand arc sieved.

8.4.3 *Sorting Coefficient* — An index to the sorting or distribution of the grains in a sand sample shall be obtained from the sorting coefficient, S_0 defined by the following formula:

$$S_0 = \frac{Q_1}{Q_3}$$

where Q_1 is the size in microns where the cumulative curve for a sand crosses the 25 percent retained line and Q_3 is the size in microns where the curve crosses 75 percent retained. Sorting coefficient is a rapid method of indicating the slope of the curve. This is also a measure of the distribution.

The range of distribution numbers shall be from 1.0 for particles of uniform size, such as ball bearings to a maximum of about 10.0. Washed and graded sands shall range from l.14 to l.40 while naturally bonded sands are usually between 1.40 and 2.50.

8.4.4 *Grain Fineness Number* — It is approximately 2.54 times the number of meshes per centimetre of that sieve which would allow to pass the sample if its grains were of a uniform size, that is, the average of the sizes of grain in the sample. It is approximately proportional to the surface area per unit weight of a sand, exclusive of clay.

8.4.4.1 *Calculation of Fineness Number* — Express the weight in grams of various sizes according to the procedure given under 8.3 as percentage of the original 50-g sample. Multiply them by the multipliers as given in Table 1. Add the products and divide the total by the sum of the percentages of sand grains. The result shall be the grain fineness number.

TABLE 1 MULTIPLIER FOR GRAIN FINENESS NUMBER

IS SIEVE	MULTIPLIER
3.35-mm	3
l.70-mm	5
850-micron	10
600-micron	20

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*Specification for test sieves (*revised*).

425-micron	30
300-micron	40
212-micron	50
150-micron	70
106-micron	100
75-micron	140
53-micron	200
Pan	300

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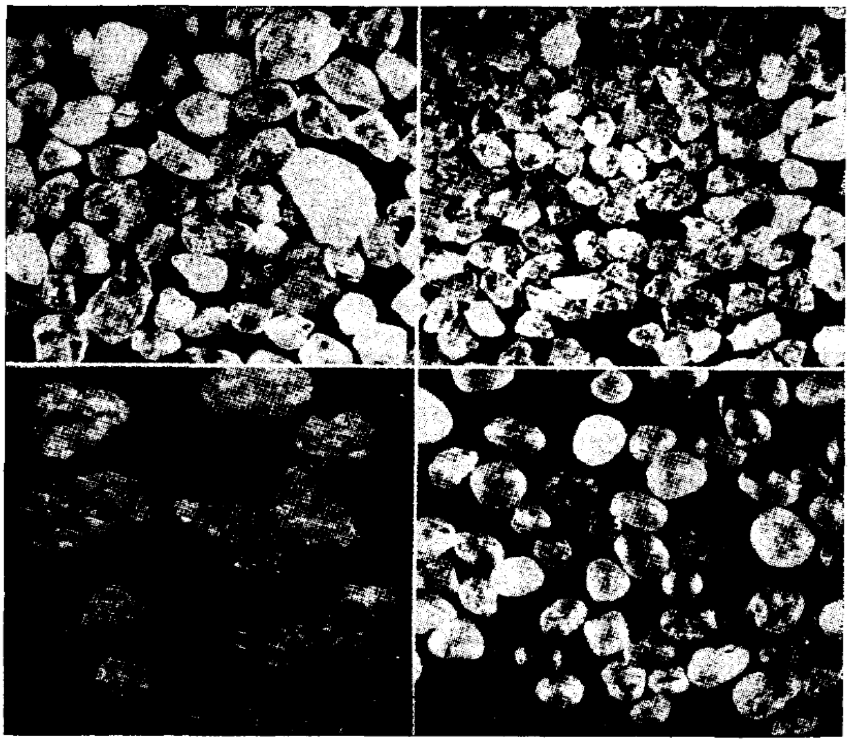
9. DETERMINATION OF GRAIN SHAPE

9.1 Apparatus — A low power stereoscopic microscope working with reflected light and giving magnifications of 30 x to 60 x.

9.2 Procedure — The grain shape shall be determined by the microscopic examination of a small portions of the grain size fractions from all the sieves and the pan at magnifications of 30 x to 60 x.

9.2.1 The grain shapes to be distinguished are rounded, subangular, angular and splintered as shown in **Fig. 2**. Identification for grain shape shall be based on the predominant grain shape of the largest fraction (by weight) of sand.



Upper Left — Angular Sand Grains
Lower Left — Subangular Sand Grains
Upper Right — Rounded Sand Grains
Lower Right — Compound and Splintered Sand Grains

FIG. 2 SAND GRAINS

10. DETERMINATION OF PERMEABILITY

Permeability is defined as that physical property of the moulded mass of sand mixture which allows gas to pass through it. It is numerically equal to the volume of air in ~~millilitres~~ millilitres that will pass per minute under a pressure of 1 gf/cm^2 through a specimen of 1 cm^2 in cross-sectional area and 1 cm high.

10.1 Determination of Base Permeability — Base permeability is the permeabilitv of packed dry sand grains containing no clay or other bonding substance.

10.1.1 *Apparatus*

10.1.1.1 *Standard Permeability Meter*

10.1.1.2 *Stop-watch*

10.1.1.3 Standard sand rammer or Sand Squeezer along with the standard specimen container (Specimen tube) and special screens to be kept at each end of the specimen to hold the bond free sand in position in the specimen tube. The screen shall be saucer shaped, one pressed within the other, the saucer being of such diameter as to just fit into the standard specimen container. The outer screen shall be of metal and perforated with at least 100 holes at the rate of 16 holes of 1.6 mm diameter per square centimetre.

10.1.2 *Procedure* — Wash the sample for its clay content in accordance with the method given under **7.3** and dry the sand grains thoroughly at 105º to 110ºC. Place a base permeability screen, with sides of the cup upward, in the bottom of the standard specimen container. Place sufficient quantity of dried sand in the specimen container to produce the standard sand test specimen. Place the second base permeability screen, with sides of the cup downward, on top of the sand in the specimen container. Ram the specimen in accordance with the method given in 5.3 ~~bbt~~ do not remove the specimen from the container. Place the specimen container with the specimen ~~in the mercury seal~~on the rubber boss –of the permeability apparatus. Find out the time required for exactly 2 000 ml of air to pass through the specimen. After the pressure has become steady, read the pressure on the pressure indicator and record in gf/cm^2.

10.1.2.1 Calculate the base permeability number (P) of the sand from the following formula:

$$P = \frac{v \times h}{p \times a \times t}$$

where

v = volume of air in ml passed through the specimen,
h = height of the test specimen in cm,
p = pressure of the air in gf/cm^2,
a = cross-sectional area of the test specimen in cm^2, and
t = time in minutes.

10.1.2.2 Test three specimens individually. The base permeability shall be the average of three tests. If the test result of one of the test specimens varies more than 10 percent from the average of three, this result shall be discarded and another specimen tested.

10.2 Determination of Green Permeability — The green permeability of foundry moulding sand is the permeability of a moulded mass of sand in its moist or tempered condition. In other words, it is the permeability of a naturally or synthetically-bonded foundry moulding

10.2.1 *Apparatus* — Same as described in **10.1.1**.

10.2.2 *Test Specimen* — The standard ~~test~~Test. specimen specified under 5 shall be used.

10.2.3 *Procedure* — Ram the standard test specimen in a specimen container and follow the procedure as given in **10.1.2**.

10.3 Determination of Dry Permeability

10.3.0 Dry permeability is defined as the permeability of a moulded mass of sand, containing clay or binders, which has been completely dried at 105° to 110°C.

10.3.1 *Apparatus* - Same as described in **10.1.1**.

10.3.1.1 Special type of split specimen container used for ramming test specimens (*see* **5.3.2**).

10.3.1.2 Standard drier

10.3.1.3 Special permeability machine attachment for the determination of dry permeability.

10.3.2 *Test Specimen* — The standard test specimen specified under 5 shall be used after drying at 105° to 110°C in the drier for a period of 2 hours and cooling to room temperature in a desiccator.

10.3.3 *Procedure* — Using the split specimen container to hold the dried specimen, determine the dry permeability as in **10.1.2**.

10.4 Determination of permeability of Resin Bonded Sands

10.4.0 Resin bonded sand specimen such as Cold Box resin bonded sand Specimen, Silicate Bonded Sand specimen do not deform in shape upon release from specimen making apparatus.

10.4.1 *Apparatus* - Same as described in **10.1.1**

10.4.1.1 Special Core permeability testing accessory capable of holding and sealing the specimen.

10.4.2 *Test Specimen* — The standard Test. specimen specified under 5 shall be used.

10.4.2 *Procedure* —Place the prepared specimen in the Special Core permeability testing accessory and seal it as per the equipment manufacturers instructions. Place the Special Core permeability testing accessory with the specimen on the rubber boss of the permeability apparatus. Find out the time required for exactly 2 000 ml of air to pass through the specimen. After the pressure has become steady, read the pressure on the pressure indicator and record in gf/cm^2. Rest of the procedure shall be as per 10.1.2.1 and 10.1.2.2.

11. DETERMINATION OF TENSILE STRENGTH

11.0 The tensile strength of a moulding sand mixture is the maximum tensile stress which the sand mixture is~~k~~ capable of sustaining when pre~~-~~pared, rammed and tested according to standard procedures.

11.1 Determination of Green Tensile Strength — Green tensile strength is the tensile strength of a foundry sand mixture in the moist or tempered condition.

11.1.1 *Apparatus* — Dead weight type of universal sand strength testing machine or spring type of sand strength testing machine.

11.1.2 *Test Specimen* — A specially designed specimen tube shall be used for making the standard test specimen (*see* **5.2**). It shall be a two-part tube designed so that the specimen may remain in the tube during testing and the two halves of the tube readily separate approximately at the middle of the specimen when it fails (*see* **Fig. 3**).

11.1.2.1 In preparing the test specimen the specimen tube is placed on its pedestal cap and the tube carefully filled with the correct weight of sand to be tested. The specimen tube and

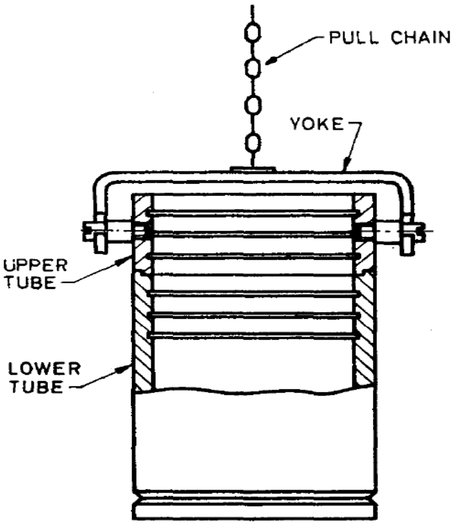


FIG. 3 SPECIMEN TUBE FOR DETERMINING GREEN AND TENSILE STRENGTH OF FOUNDRY SANDS

11.1.3 *Procedure* — Place the rammed specimen contained in the specimen tube in the specimen tube holder and hold firmly by means of two clamp screws. Apply a uniform load along the axis of standard test specimen at the rate not exceeding 1.5 ± 0.5 gf/mm^2 per minute until the specimen breaks. Record. the breaking load in grams and calculate the tensile strength in kgf/cm^2 by dividing the breaking load with area of rupture section.

11.1.3.1 An average of three tensile tests shall be taken. If the test result of one of the three varies more than 10 percent from the average of three, this result shall be discarded and another specimen tested.

11.2 Determination of Dry Tensile Strength — Dry tensile strength is the tensile strength of a foundry sand mixture which has been dried at 105° to 110°C and cooled to room temperature in a desiccator.

11.2.1 *Apparatus* — Same is described in **11.1.1** together with a standard drier.

11.2.2 *Test Specimen* — The standard test specimen contained in the specimen tube (*see* **11.1.2** and **11.2.1**) shall be used after drying at 105° to 110°C in a drier for a period of 2 hours or until dry, and cooling to room temperature.

11.2.3 *Procedure* — Test the dried specimen in the specimen tube as under **11.1.3.** In this ~~test~~ Test the rate of loading shall not exceed 10.0 ± 1.5 gf/mm^2 per minute.

12. DETERMINATION OF COMPRESSION STRENGTH

12.1 Determination of Green Compression Strength — The green compression strength of a foundry moulding sand is the maximum compressive stress in $\mathrm{gf/mm^2}$ which the sand in unbaked condition is capable of withstanding.

12.1.1 *Apparatus* — Dead weight type of universal sand strength testing machine or spring type of sand strength testing machine~~.~~ or Digital read-out type loadcell based equipment.

12.1.2 Test *Specimen* — The standard test specimen specified in 5 shall be used.

12.1.3 *Procedure* — Ram a standard test specimen and strip it from the specimen container. Place the test specimen in the compression machine in such a manner that the top of the specimen as rammed in the specimen container rests against the upper head of the machine. Apply a uniform load against the plane faces of the specimen so that the force is axial at a rate of 21± 4 $\mathrm{gf/mm^2}$ per minute until the specimen breaks Record the load at rupture.

12.1.3.1 Calculate the green compression strength from the following formula:

$$\text{Green compression strength, gf/mm}^2 = \frac{F}{A}$$

where

F = load at rupture in gf, and
A = cross-sectional area of the test specimen in $\mathrm{mm^2}$

12.1.3.2 Test three specimens individually. The compressive strength shall be the average of three tests. If the test result of one of the specimens varies by more than 10 percent, from the average of the three this result shall be discarded and another specimen tested.

12.2 Determination of Dry and Baked Compression Strength — Dry compression strength is the maximum compressive stress in $\mathrm{gf/mm^2}$ which a dry sand mixture is capable of developing. In case the test specimen has been baked at a specified temperature above 110°C, the maximum compressive stress in $\mathrm{gf/mm^2}$ developed is known as 'baked compression strength'

12.2.1 *Apparatus* — Same as specified in **12.1.1.**

12.2.2 *Test Specimen* — The standard test specimen specified in **5** shall be used.

12.2.2.1 *Drying* — When the ~~test~~ Test is applied to sands for use in green sand moulds, the specimen shall be dried on a flat, rigid plate in a ventilated oven and allowed to cool to room temperature in a desiccator. Test the specimen after it has reached the room temperature.

12.2.2.2 *Baking* — When the ~~test~~ Test is applied to sands used for dry sand moulding or to other mixtures which would normally be baked at a temperature higher than 110°C, a baking temperature and time which is suitable for that particular mixture should be used.

12.2.3 *Procedure* — The standard test specimen after removal from the specimen container shall be dried or baked and cooled as specified in **12.2.2**. The specimen should be placed in the apparatus with the same side against the compression head which was uppermost in the specimen container during ramming. Apply a uniform load against the plain surfaces of the specimen so that the force is axial at a rate of 100 ± 15 $\mathrm{gf/mm^2}$ per minute, until the specimen Breaks. Record the load at rupture. Calculate the dry or baked compression strength as under **12.1.3.1.**

13. DETERMINATION OF SHEAR STRENGTH

13.1 Determination of Green Shear Strength — The green shear strength of sand is the maximum shear stress which a tempered sand mixture is capable of developing.

13.1.1 *Apparatus* — Universal standard sand testing machine with shear strength attachment.

13.1.2 *Test Specimen* — The standard test specimen specified in **5** shall be used**.**

13.1.3 *Procedure* — Ram a standard test specimen and strip from the specimen container. Place the specimen between the shear heads of the machine in such a way that the load is applied along a line through its axis. Apply a uniform load to the diametrically opposite halves of the two plain surfaces of the specimen at the rate of 17 ± 4 gf/mm^2 per minute. Record he breaking load in kg and calculate the shear strength in gf/mm° by dividing the breaking load by area of rupture section.

13.1.3.1 Test three specimens individually. The sheer strength shall be the average of three tests. If the test result of one of the specimens varied more than 10 percent, from the average of the three, this result shall be discarded and another specimen tested.

13.2 Determination of Dry Shear Strength — The method given in **13.1** shall be employed for the determination of dry shear strength, except that the test specimen shall be dried at 105° to 110°C for 2 hours or until dried, and allowed to cool in a desiccator to room temperature before testing.

14. DETERMINATION OF BULK DENSITY

14.1 Determination of Bulk Density Before Compression

14.1.1 *Procedure* — Take 500 g of tempered sand mixture as prepared under 4 and allow it to fall in a one-litre measuring cylinder through a perforated disc rotating slowly at the 1000 ml mark. After the whole sand has dropped into the measuring flask, even out the sand surface by slightly pressing with the perforated disc. The ratio of the mass of the sand to the volume occupied by it will represent the bulk density before compression in grams per millilitre (g/ml).

14.2 Determination of Bulk Density after Compression

14.2.1 *Apparatus* — Standard rammer and physical balance.

14.2.2 *Test Specimen* — The standard test specimen specified in **5** shall be used.

14.2.3 *Procedure* — Ram a standard test specimen as given in **5.3.** Weigh it in a balance and also calculate. its volume from its dimensions. The ratio of the weight of the specimen to the volume will give the bulk density after compression in g/ml.

15. DETERMINATION OF GREEN MOULD SURFACE HARDNESS

15.0 Green mould surface hardness is the resistance offered by the surface of a green sand mould to penetration~~.~~ by a loaded plunger.

15.1 *Apparatus* — Standard mould surface hardness tester**.**

15.1.1 *Test Specimen* — The standard test specimen specified in **5** shall be used.

15.1.2 *Procedure* — Bring the unloaded plunger of the tester in contact with the mould surface. Apply the load to the plunger and read the hardness number, on the graduated dial of the testing apparatus.

NOTE — The ~~test~~ Test is performed on standard test specimen papered as given in **5** or on the mould itself.

The ~~test~~ Test should be performed immediately after the specimen is stripped from the tube or the pattern is withdrawn from the mould.

16. DETERMINATION OF FLOWABILITY

16.0 In general the term ‘flowability’ refers to the movement of sand grains when they are subjected to moulding forces.

16.1 Apparatus — Standard sand rammer together with the standard flowability meter.

16.2 Test Specimen — The standard test specimen specified in **5** shall be used.

16.3 Procedure — Read the percent flowability on the dial of the flowability meter after. the fifth drop of the ramming weight. The stem of the flowability meter rests against the top of the plunger of the rammer and registers the movement of the rammer plunger between the fourth and fifth drops as percentage flowability.

16.3.1 Test three specimens individually. The flowability number shalt be the average of three tests. If the test result of one of the specimens varies more than 10 percent from the average of three, this result shall be discarded and another specimen tested.

17. DETERMINATION OF SHATTER INDEX

17.1 Test Specimen — The standard test specimen specified in **5** shall be used.

17.2 Procedure — Ram a standard test specimen by 10 blows in accordance with the method given in **5.3** and allow it to fall from a height of 1830 mm. Collect the portion of the sand retained on. 12-mm IS Sieve. The percent weight retained shall be the shatter index.

18. DETERMINATION OF SINTERING POINT

18.1 Determination of Sintering Point of High-Silica Sand — Sintering point of high-silica sand shall be determined in accordance with the method given under **~~3~~4** of IS 1528 (Part 1) ~~IS : 1526-1962~~*.

Commented [PAJ1]: This needs correction with correct standard number

18.2 Determination of Sintering Point of Foundry Sand Mixtures

18.2.1 *Apparatus*

18.2.1.1 *Porcelain combustion boats* of 75 to 90 mm length and 10 to 15 mm width.

18.2.1.2 *Electric furnace* — with a testing temperature of at least 1500°C.

18.2.2 *Procedure* — Loosely fill the sand sample in the combustion boat and place the boat in the hot zone of the electric furnace. When temperature has reached 1000°C keep the temperature constant for at least 3 minutes. Take out the boat from the furnace, cool and observe whether the sintering of the sand grain has started. If not sintered, replace the combustion boat in the furnace and continue the ~~test~~ Test with temperature increments of 50°C till sintering occurs. Keep the combustion boat at each particular temperature for at least 3 minutes. After cooling, examine the sand sample for sintering by scraping or visual examination with a magnifier or microscope.

18.2.3 *Determination of 'A' Sintering Point of Foundry Sand Mixtures* — 'A sintering point is the lowest temperature at which the ribbon used in the sintering test makes a 'V' when lifted off the sand specimen.

NOTE -The 'V' determination is applicable to practically all types of sands except sands with very low dry strength.

18.2.3.1 *Apparatus* — Standard equipment for the determination of 'A' sintering point.

18.2.3.2 *Test Specimen* —The standard test specimen as specified in **5** and dried for at least one hour at 105° to 110°C.

18.2.3.3 *Procedure* — Place the send specimen in position in the sintering apparatus under the platinum ribbon heater. Centre the specimen between the platinum ribbon holder terminals and place the platinum ribbon in contact with the rounded surface of the sand specimen, allowing 170-g load to be applied to the ribbon. Sight the optical pyrometer on the central part of the platinum ribbon and adjust it to rend the desired temperature. Allow for the emissivity of platinum as given in Table 2. Pass an electric current through the platinum ribbon and adjust the variable resistance so that the brightness of the platinum ribbon matches the brightness of the, filament or dot in the optical pyrometer, which has been set at the desired temperature. Heat to required temperature in about 30 seconds and start a stop-watch and allow the heated ribbon to remain in contact with the specimen to cool for exactly 15 seconds. Lift up the ribbon holder and ribbon and observe whether the ribbon adheres to the sand specimen and makes a 'V' when it is lifted. Rotate the specimen about 50 mm to a fresh surface and again place the platinum ribbon in contact with the specimen. All adhering material should be removed from the ribbon by scraping or dissolving in hydrofluoric acid after each individual determination. If the ribbon did not make a 'V' repeat the above procedure, this time increasing the true temperature by about 23 deg. This corresponds to an increase in the observed temperature of about 22 deg. The actual values should be taken from Table 2. Repeat the above procedure either by increasing or decreasing the true temperature by increments or decrements of 25 deg, until ribbon does not make a definite 'V' at one temperature, but does at the next higher temperature. The lowest true temperature at which the platinum ribbon makes a definite 'V' when lifted off the sand specimen 15 seconds after the 4-minute heating period is the 'A' sintering point

TABLE 2 TEMPERATURE CORRECTIONS FOR EMISSIVITY OF PLATINUM

(*Clause* 18.2.3.3)

OBSEBVED TEMPEEATUFCE °C	TRUE TEMPEEATUFCE °C
917	1000
939	1025
96t	1 050
1 005	1 075
1 027	1 125
1 045	1 150
1 070	1 175
1 091	1 200
1 113	1 225
1 134	1 250
1 156	1 275
1 177	1 300
1 199	1 32â
1 220	1 350
1 242	1 375
1 263	1 400
1 284	1 425
1 305	1 450
1 326	1 475
1 348	1 500
1 369	1 525
1 390	1 550
1 411	1 575
1 432	1 600
1 452	1 625
1 473	1 650
1 494	1 67â
1 515	1 700
1 536	1 72a

18.2.4 *Determination of 'B' Sintering Point of Foundry Sand Mixtures* – 'B' sintering point is the lowest temperature at which the smaller sand grains show signs of fusion.

18.2.4.1 *Apparatus* — *Same* as specified in **18.2.3.1.**

18.2.4.2 Test *specimen* — The standard test specimen specified in 5 shall be used.

18.2.4.3 *Procedure* — *The* method to be adopted shall be the same as for the 'A' sintering point test, except that the platinum ribbon shall be lifted from the sand specimen immediately after the electric current is shut off, so as to preserve the surface in contact with the ribbon. The 'B' sintering point is the lowest temperature which causes traces of fusion to be seen at 20 to 25 diameter magnification. In the scraper method 2 minutes interval shall be allowed after turning of the electric current before lifting the platinum ribbon from the sand specimen. The ribbon is removed from the holder, placed on a flat plate and scraped. The 'B' sintering point by this method shall be the lowest temperature which necessitates 50 passes of a mechanical scraper to remove the sand from the ribbon. The scraper shall be of such design as to apply 113 g load to a knife-edge in contact with the ribbon during scraping. The knife-edge shall be at 140° angle with the plane of the ribbon.

SECTION 3 METHODS OF PHYSICAL TESTS FOR FOUNDRY CORE SANDS

19. DETERMINATION OF MOISTURE CONTENT

19.1 Direct Weight Method — Same as given in **6.1.**

19.2 Calcium Carbide Method — Same as given in **6.2**.

20. DETERMINATION OF CLAY CONTENT

20.1 Same as given in 7**.**

21. DETERMINATION OF GRAIN FINENESS

21.1 Same as given in **8**.

22. DETERMINATION OF GRAIN SHAPE

22.1 Same as given in **9.**

23. DETERMINATION OF PERMEABILITY

23.1 Determination of Base Permeability — Same as given in **10.1.**

23.2 Determination of Green Permeability — Same as given in **10.2.**

23.3 Determination of Dry Permeability — Same as given in **10.3.**

23.4 Determination of Baked Permeability — Baked permeability is the permeability of a moulded mass of sand baked at a temperature higher than 110°C and then cooled to room temperature.

23.4.1 *Apparatus* — The apparatus specified in **10.3.1** and a core baking oven of the following specification:

> The oven shall be capable of giving uniform temperature up to 320°C and shall be equipped with automatic regulator to maintain an even and uniform oven temperature with a variation not greater than 5 deg over the entire temperature range. Openings shall be provided through which baked cores may be removed at different intervals, when testing for baking time, without causing a drop in temperature of more than 5 deg. The input of heat shall be such that, after putting in the charge, the oven shall return to the desired baking temperature in 20 minutes.

23.4.2 *Test Specimen* — Same as specified in **10.3.2**.

23.4.3 *Procedure* — Same as specified in **10.3.3**.

NOTE — The permeability needed for a given core depends on the amount of gas-forming materials in the sand mixture used.

24. DETERMINATION OF STRENGTH

24.1 Green Compression Strength — Same as given in **12.1.**

24.2 Baked Compression Strength — Same as given in **12.2.**

24.3 Determination of Baked Tensile Strength — The baked tensile strength of a core sand mixture is the maximum tensile stress in gf/mm2 which a core made out of this mixture will develop in the baked condition. It is an index to core breakage and is a function of the type of binder used**.**

24.3.1 *Apparatus*

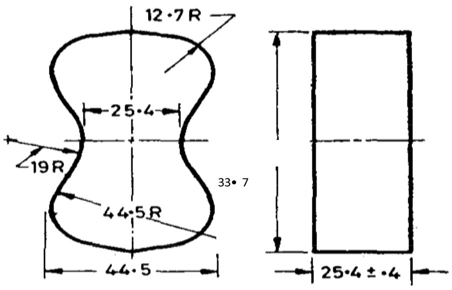
24.3.1.1 *Universal Standard Sand Testing Machine* — with tensile strength attachment.

24.3.1.2 *Standard sand rammer — with* the equipment for making briquette type of special test specimens.

24.3.1.3 *Standard Baking Oven for Core*

24.3.2 *Test Specimens*

24.3.2.1 The test specimens shall be of shape and dimensions given in **Fig. 4** or shall have a rupture section or of 22.36 x 22.36 mm that is 5 cm^2.



All dimensions in milimetres.

FIG. 4 TEST SPECIMENS FOR TESTING TENSILE STRBNGTH OF CORES AND MIXTURE

24.3.2.2 A two-part metal core box, provided with a loading hopper, ramming plate, and rammer head which may be attached to a standard rammer used for making test specimen.

24.3.2.3 Baking of test specimens- Bake a number of test specimens under the following conditions:

a) at 180°C for $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2 and $2\frac{1}{2}$ h,

b) at 220°C for $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2 and $2\frac{1}{2}$ h, and

c) at 250°C for $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2 and $2\frac{1}{2}$ h.

24.3.2.4 After baking allow the core specimens ro cool, preferably in a desiccator. Any test specimens showing an imperfection shall be rejected. Caliper each test specimen to check dimensions. Reject the specimens if any dimension is not within ± 5 percent. The specimen shall be tested as soon as possible after having reached room temperature.

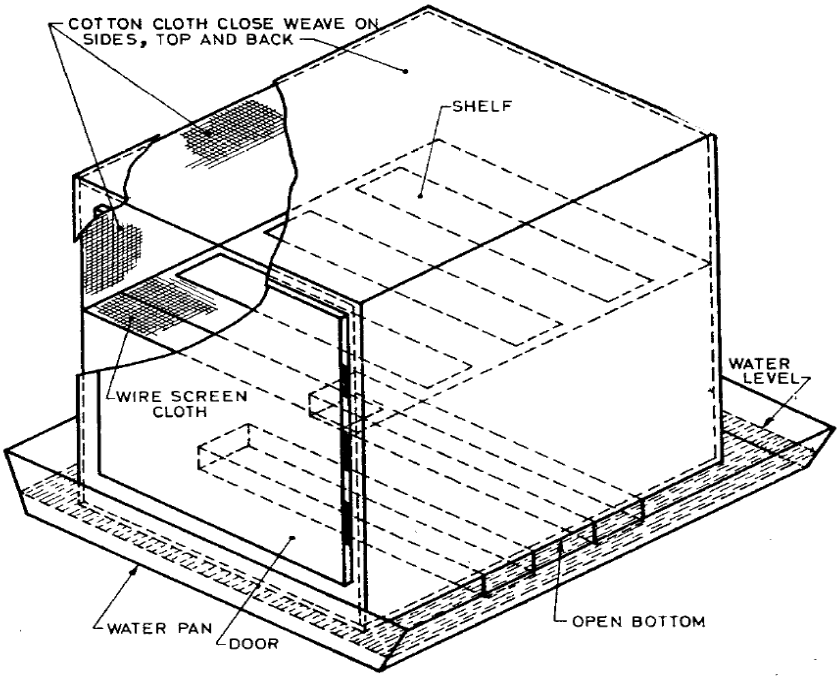
24.3.3 *Procedure* — Fit the grips for pulling tensile test specimens in the universal testing machine. Place the specimen into the grip of the machine in such a way that it is gripped uniformly along with the lateral surfaces and so that the load is applied along a line through its axis. Apply load at the rate of 40 ± 5 gf/mm^2 per minute. Record the breaking load in kilograms and calculate the tensile strength in gf/mm^2, by dividing the breaking load with area of rupture section.

24.3.3.1 An average of the three tensile tests at each baking time and temperature (*see* **24.3.2.3**) shall be taken. If the test result of one of the three varies more than 10 percent from the average of three, this result shall be discarded and another specimen tested. From these results the optimum baking temperature and time to get the maximum tensile strength shall be deduced.

24.4 Humidity Test and Determination of the Loss of Baked Strength Under Humid Conditions

24.4.1 *Apparatus* — Same as specified in **24.3.1**.

24.4.1.1 *Humidity chamber* — *See* Fig. 5.



All dimensions in millimetres.

FIG. 5 HUMIDITY TEST CHAMBER (SHELF AREA 500 x 375 mm APPROX)

24.4.2 *Test Specimens* — The test specimens specified in **24.3.2** shall be used.

24.4.3 *Procedure* — Bake a sufficient number of standard tensile test specimens at the optimum temperature for the optimum period of time (*see* **24.3.2.1**). Cool them to room temperature in a desiccator. Test three samples to give average tensile strength. Place the remaining test specimens in the humidity chamber, and test for tensile strength, three at a time after 1, 2, 4 and 8 hours in humid atmosphere. Find the average loss in tensile strength, and plot as a percentage of the original, tensile strength of the specimens with the time interval.

24.5 Determination of Baked Transverse Strength — The baked transverse strength of a core is the load per unit area required to break a standard test bar of specified dimensions made out of core-sand mixture, when the load is applied midway between the ends of the test bar.

24.5.1 *Apparatus*

24.5.1.1 *Universal testing machine* — with the attachment *for* transverse ~~test~~Test

24.5.1.2 *Standard sand rammer*

24.5.1.3 *Special core box assembly* — with a drier plate and hopper and a rammer head to be attached with the standard rammer.

24.5.1.4 *Standard baking oven*

24.5.2 *Test Specimens*

24.5.2.1 The test bar shall have the dimensions 25.4 x 25.4 x 203.2 mm or having a square section of 22.36 x 22.36 mm, that is, a section of 500 mm^2 and a length of about 170 mm.

24.5.2.2 Ram three test bars and strip them from the core box on a core plate. Bake the test specimens at the optimum temperature for the optimum period.

24.5.3 *Procedure* — Place the test specimens on the supports of the testing machine in the same relative position in which it was baked. Apply a load midway between supports at the rate of 80 ± 12 gf/mm^2 per minute. Record the breaking load in grams.

24.5.3.1 Calculate the transverse strength from the following formula:

$$\text{Transverse strength, gf/mm}^2 = \frac{3\,wl}{2\,bd^2}$$

where,

W = total load in gf at which the failure occurs,

l = distance between supports in mm,

b = width of the test specimen in mm, and

d = thickness of the test specimen in mm.

24.5.3.2 An average of the results of three tests conducted on three individual test specimens shall be reported as the transverse strength. If the test result of one of the test specimens varies, more than 10 percent from the average of the three, this result shall be discarded and another specimen tested.

25. DETERMINATION OF BULK DENSITY

25.1 Same as given in **14.**

26. DETERMINATION OF BAKED SCRATCH HARDNESS

26.0 Baked scratch hardness is a measure of the ability of the core to withstand abrasion during the handling operation from the baking oven to the mould. A core with high scratch hardness is more likely to go into the mould with its edges and surfaces having the exact contours of the core box. All other things being equal, a core which has a low scratch hardness may be abraded in handling and therefore give a casting which has a poorer surface finish then desired.

26.1 Apparatus — Standard baked core hardness tester.

26.1.l *Test Specimens* — The hardness shall be tested on the tensile or transverse test specimens baked at optimum temperature for the optimum period (*see* **24.3.2** and **24.3.2.3**).

26.1.2 *Procedure* — Hold the hardness tester in the right hand and press it against the surface of the test specimen. This will give an indentation hardness value. Slowly pull the tester across the surface to be tested, making sure that the knife-edge is parallel to the long edge of the tester. The hardness of the surfaces will be indicated on the dial. Perform the ~~test~~ Test at three different locations over the specimen and the average of three such readings shall be recorded as hardness number.

27. DETERMINATION OF GAS GENERATED IN A CORE DURING BAKING

27.0 The amount of gas generated within a core during baking, pouring and solidification of the metal is of considerable importance of foundry-men. Since ample 'venting' of cores and moulds has to be provided for removal of this gas, both the volume of gas and the rate at which it is evolved are important.

27.1 Apparatus — Core gas determinator with accessories

27.1.1 *Test Sample* — Broken halves of baked tensile or transverse test specimens shall be used. Dry all specimen material to constant weight at 105° to 110°C and cool in a desiccator. Rub two sections of the core specimens together over a suitable piece of paper in order to obtain a cross- sectional representative sample, alternatively core sand may be pulverized o pass entirely through 1.70-mm IS Sieve (*see* IS : 460-1962*).

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*Specification for test sieves (*revised*).

27.1.2 *Procedure* — Weigh accurately about 2 to 3 g of the test sample in tared combustion boat or suitable crucible which has been pre-heated and cooled in a desiccator. Keep it in a desiccator between the time of weighing and testing.

27.1.3 Place the sample in the combustion tube and heat it in an atmosphere of carbon dioxide or nitrogen (non-oxidizing) at 1000°C and collect the gas evolved. Record the volume of the gas collected in the burette after every 0.5 Seconds. Record also the final volume of the gas evolved. This may require as much as 10 to 12 minutes.

27.1.3.1 Calculate the volume in millilitres of gas evolved per gram of the sample from the following formula:

$$\text{Gas in ml/g} = \frac{\text{Total corrected gas volume in ml}}{\text{Sample weight in gdx}}$$

If it is desired to reduce the volume of gas to NTP (normal temperature and pressure), correction shall be made for mean barometric pressure and temperature.

27.1.3.2 For the rate of gas evolution, divide the gas volume by the sample weight to obtain the reading in ml/g, for each time interval. Plot these vaIues against time interval to indicate the rate of gas evolution.

28. DETERMINATION OF SINTERING POINT

28.1 Same as given in **18.2.**

AMENDMENT NO. 1 JANUARY 2013

TO
IS 1918 : 1966 METHODS OF PHYSICAL TESTS FOR FOUNDRY SANDS

(*Page* 8, *clause* **7.3.1.1**) — Insert the following Note at the end of the clause:

> NOTE — The least count for weighing shall be commensurate with maximum permissible clay content. For example, least count 0.01 g for maximum of 0.2 percent clay content based on a sample of size 50 grams.

A table as guide for ready reference of the user, for sample size 50 g is given below:

Upper Limit		*Least Count*
Percent	g	g
Equal to or more than 20	≥ 10	1
Equal to or more than 10, up to 20	≥ 5, up to10	0.5
Equal to or more than 2, up to 10	≥1, up to 5	0.1
Equal to or more than 1, up to 2	≥ 0.5, up to 1	0.05
Equal to or more than 0.2, up to 1	≥ 0.1, up to 0.5	0.01
Equal to or more than 0.1, up to 0.2	≥ 0.05, up to 0.1	0.005
Less than 0.1	< 0.05	0.001

(MTD 14)

Reprography Unit, BIS, New Delhi, India