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मानक

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Mazdoor Kisan Shakti Sangathan

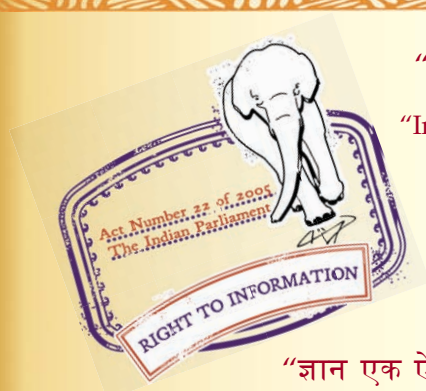
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“पुराने को छोड़ नये के तरफ”

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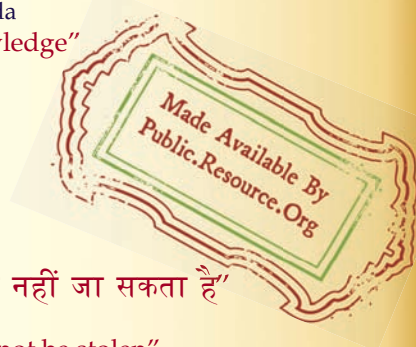
IS 12446 (2007): Bentonite for use in foundries [MTD 14: Foundry]



“ज्ञान से एक नये भारत का निर्माण”

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“Invent a New India Using Knowledge”



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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भारतीय मानक
ढलाई में प्रयुक्त बेन्टोनाइट — विशिष्टि
(पहला पुनरीक्षण)

Indian Standard
BENTONITE FOR USE IN FOUNDRIES —
SPECIFICATION
(*First Revision*)

ICS 81.080

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Foundry and Steel Casting Sectional Committee had been approved by the Metallurgical Engineering Division Council. This standard was first published in 1988.

Foundry grade bentonite was earlier covered in IS 6186 : 1971 'Specification for bentonite' covering the requirements and the methods of sampling and test for bentonite for use in chemical industries, oil well drilling and foundry. It was revised in 1986, in the revised standard, the material used for foundry was deleted. Subsequently it was felt that a separate Indian Standard should be formulated on the foundry grades of bentonite, since the foundry grades bentonite have different characteristics and problems.

Bentonite is a natural product. It is ground in mills after treatment/blending to very fine powder. Bentonite is basically composed of the mineral montomorillonite which occurs in extremely fine particles. Bentonite also contains beidelite (montomorillonite family) as principal mineral. Bentonite is mixed with sand to impart plasticity and strength to it in the presence of moisture. The fine particle size and high moisture absorption, that is, high swelling property of bentonite give bonding strength or adhesion to the mass of sand grains.

This standard keeps in view the quality of bentonite available in the country and known to be commercially exploited. Sodium base bentonite deposits are available in:

- a) Wandh village near Manvi, Kutch, Gujarat;
- b) Barmer, Aaklee, Visala and Hathi Ki Dhani, Rajasthan; and
- c) Mahua, Lakhnoka, Malpur and Bhawnagar region in Gujarat.

Calcium base bentonite deposits are available in:

- a) Bakuda and Tinpahar in Bihar,
- b) Rajula and Bhavnagar in Gujarat,
- c) Madras suburbs, and
- d) Kashmir.

Important relative differences in properties of sodium and calcium based bentonites are given below:

<i>Properties</i>	<i>Predominant Exchangeable Cation (Total of Interlayer and Extraneous)</i>	
	<i>Sodium (Na)</i>	<i>Calcium (Ca)</i>
(1)	(2)	(3)
Swelling	High	Low
Plasticity	Lower	Higher
Rigidity of	Lower	Higher
Absorbed water layer	(first three molecular layer)	(first four molecular layer)
Liquid limit	Higher	Lower
Green strength	Slightly lower	Higher
Dry strength	High	Low
Hot strength	Very high	Low

For the purpose of deciding 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 in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

BENTONITE FOR USE IN FOUNDRIES — SPECIFICATION

(First Revision)

1 SCOPE

This standard covers the requirements for bentonite used as a binder for preparing the moulding sand etc in foundries.

2 REFERENCES

The standards listed below contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	Title
1070 : 1992	Reagent grade water (<i>third revision</i>)
1387 : 1993	General requirements for supply of metallurgical materials (<i>second revision</i>)
3018 : 1977	Specification for standard silica sand for raw material testing in foundries
10214 : 1982	Methods of sampling bentonite

3 DESIGNATION

It is to be designated as;

Bentonite

- 00 — Denotes the MB value (Methylene Blue Value in mg of MB/g of bentonite)
- 100 — Denotes the predominant action say Sodium — Na and Calcium — Ca

Example:

- a) Bentonite — Na 450 — IS 12446
- b) Bentonite — Ca 230 — IS 12446

4 GRADES

4.1 Sodium base bentonite is covered in two grades, namely:

- a) Na 450
- b) Na 370

4.2 Calcium base bentonite is covered in one grade, namely, Ca 220.

5 PROPERTIES

5.1 Bentonite is to be of uniform quality and when tested in accordance with the methods specified in Annex A, it is to conform with the values given in Table 1.

5.2 Physical Condition

Very fine dry powder with creamy feel, free from dirt lumps, grits, sand and other foreign materials and impurities. Colour is creamy yellowish, pale buff, grey to light grey.

5.3 Chemical Composition

The chemical formula of bentonite is $(Al, Fe_{1.67}Mg_{0.33})Si_4O_{10}(OH)_2Na$ plus $Ca_{0.33}$ and its approximate chemical composition in percentage is:

SiO ₂	45-65	CaO	1-5
Al ₂ O ₃	14-25	Na ₂ O	0.4-2.51
FeO + Fe ₂ O ₃	3-9	K ₂ O	0.5-1.5
MgO	2-3.5	TiO ₂	0.8-2
		Na/Ca	4.55-2.5 (Na base) 0.16-0.000 (Ca base)

5.4 Chemical and Physical Properties

Physical and chemical properties of all the grades are given in Table 1.

Specific gravity 2.0-2.2

6 SUPPLY OF BENTONITE

General requirements relating to the supply of bentonite is to conform to the conditions laid down in IS 1387.

7 SAMPLING

7.1 Procedure

Representative sample is to be drawn in accordance with the procedure given in IS 10214. The following procedure is to be followed if agreed to between the manufacturer and the purchaser.

Table 1 Requirements for Bentonite
(Clauses 5.1 and 5.4)

SI No.	Characteristics	Bentonite Grade			Methods of Test, Ref to clause
		Sodium base		Calcium base	
		Na 450 (3)	Na 370 (4)	Ca 220 (5)	
(1)	(2)	(3)	(4)	(5)	(6)
i)	Fineness				
a)	Dry				
	Maximum percent retention by mass on IS sieve sizes	3	3	3	A-2
	125 micron				
	63 micron	7	7	7	
	pan	90	90	90	
b)	Wet				
	Maximum percent retention by weight on IS sieve	5	5	5	
	45 micron				
ii)	Moisture content	6-12	6-18	5-12	A-3
iii)	pH at 2 percent suspension	9.0-10.5	9.0-10.5	8.0-9.0	A-4
iv)	Liquid limit (SFSA Method)	800-900	600-800	100-200	A-5
v)	Gel formation index, in ml	60, <i>Min</i>	50, <i>Min</i>	30, <i>Min</i>	A-6
vi)	Free swelling capacity, in ml	36, <i>Min</i>	28, <i>Min</i>	10, <i>Min</i>	A-7
vii)	Gelling time, in min	1, <i>Max</i>	2, <i>Max</i>	5, <i>Max</i>	A-8
viii)	Swelling index, in ml	33, <i>Min</i>	25 <i>Min</i>	10, <i>Min</i>	A-9
ix)	Cation exchange capacity:				
a)	mg of MB/g of bentonite	450, <i>Min</i>	370, <i>Min</i>	220, <i>Min</i>	A-10
b)	meq of MB/100 g of bentonite	120, <i>Min</i>	98, <i>Min</i>	59, <i>Min</i>	
x)	Cone fusion temp, °C	1 300	1 300	1 175-1 225	A-11
xi)	Bonding properties				
	Bentonite 7 percent moisture percent				
	High silica sand AGS-250 to				
	355 micron				
	CCS, g/cm ²	1 000, <i>Min</i>	1 000, <i>Min</i>	800, <i>Min</i>	A-12
	CCS, g/cm ²	500, <i>Min</i>	500, <i>Min</i>	400, <i>Min</i>	
	DCS, g/cm ²	5 000, <i>Min</i>	5 000, <i>Min</i>	5 000, <i>Min</i>	
	Shatter index, percent	75-80	75-80	55-60	
xii)	Chemical composition 12.1, Replaceable CA **	0.7, <i>Max</i>	0.7, <i>Max</i>	1.5-3.0	A-13
	as CaO by mass in percent				
a)	Na ₂ O, K ₂ O	3-2.5 percent	3-2.5 percent	0.75-3 percent	
b)	Na ₂ O/CaO		1.0-1.7	0.1-0.4	
xiii)	LOI	10, <i>Max</i>	10, <i>Max</i>	10, <i>Max</i>	A-14
xiv)	Na ⁺ /Ca ⁺⁺	2.5-4.5	2.5-4.5	0.001-0.4	A-13

Lot Size (Bags)	No. of Bags to be Selected for Sampling	Method of Sampling
<i>N</i>	<i>n</i>	
Up to 25	3	$N / n = r$
26-50	4	
51-100	5	Count 1, 2, 3 up to <i>r</i> and
101-200	6	so on where <i>r</i> is integral
		part of <i>N/n</i> ,
201 and above	8	Take all the <i>r</i> th bags to
		form the sample

From each of the bags selected above, a portion of the bentonite about 40 g is to be drawn with the help of a sampling instrument. Out of the portion each bag, equal

quantities of bantonite is to be taken and mixed though to form a complete sample of about 1 kg.

8 PACKING AND MARKING

8.1 Packing

Bentonite is to be supplied in water/moisture proof 40 kg sealed bags of one of the following material.

- a) Polythene line hessian bag : Fresh
- b) Polythene line hessian bag : Second hand
- c) High density polyurethane : Fresh bags
- d) High density polyurethane : Second hand bags

NOTE — Empty bags of insecticide/pesticide supply not to be used.

8.2 Marking

8.2.1 All bags are to be clearly marked with the following:

- Designation;
- Batch No. and lot No.;
- Brand name;
- Manufacturer's name, trade-mark;
- Net weight. Marking should not disfigure by water or sun-rays; and
- Manufacturing date.

8.2.2 BIS Certification Marking

The material may also be marked with the Standard Mark.

8.2.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

ANNEX A

(Clause 5.1)

METHODS OF TEST FOR BENTONITE

A-1 BENTONITE AND REAGENTS

A-1.1 Bentonite

Bentonite is highly hygroscopic. Hence either the bentonite should be taken immediately after drying to constant weight for the tests or the weight of the bentonite is to be adjusted for moisture in as it is supplied condition. Therefore, wherever weight of dried bentonite is written the weight is to be corrected for moisture and this corrected weight of the bentonite, in as it is supplied condition, is to be taken.

A-1.2 Procedure

Moisture is first found out. Therefore, weight of undried bentonite is calculated for the weight of dried bentonite which is referred for all tests.

A-1.2.1 Calculation

$$W_{UD} = \frac{W_D}{\frac{\text{moisture percent}}{100}}$$

where

W_{UD} = mass of undried bentonite (that is, as supplied condition), in g; and

W_D = mass of dried bentonite, in g.

Moisture percent = Moisture percent of the supplied bentonite under test (see A-3).

A-1.3 Quality of Reagents

Unless specified otherwise pure chemicals and distilled water (see IS 1070) is to be employed in the tests.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affects the results of analysis.

A-2 FINENESS

A-2.1 Dry Fineness

A-2.1.1 Dry about 200 g of the bentonite in the tared porcelain dish covered with a watch glass uniformly over the bottom of the dish. Keep it in air oven maintained at $105^\circ\text{C} \pm 2^\circ\text{C}$ for 2 h. Cool in desiccator and weigh till constant weight. Take 50 g from the dried sample and sieve it in the normal manner using 125 micron, 63 micron IS sieves and pan for 15 min.

A-2.1.2 Weigh the amount of bentonite retained on the IS sieves 125 micron, 63 micron and pan. Report the results as percentage weight of bentonite retained on these sieves.

A-2.2 Wet Fineness

A-2.2.1 Procedure

Weigh accurately about 10 g of the dried bentonite and place it in a 500-ml capacity bottle and add gradually 350 ml of pure distilled water (7.0 pH). Shake the mixture thoroughly in a suitable shaking machine for a period of 3 h, giving at least 30 complete inversions to the bottle per minute. The mixture thus prepared shall be fluid and free from lumps.

A-2.2.2 Sieve this mixture through IS sieve size 45 micron. Wash the residue on the sieve, dry it and weigh. Report the results as percentage weight of the bentonite retained on IS sieve size 45 micron. Drying temperature is to be within 105–110°C. It shall not exceed 110°C under any circumstances.

A-3 MOISTURE CONTENT

A-3.1 Procedure

Weigh accurately about 10 g of the material in a tared porcelain dish, covered with a watch glass. Spread the material uniformly over the bottom of the dish. Keep it in air oven maintained at $105 \pm 2^\circ\text{C}$ for 2 h. Cool the dish in a desiccator and weigh. Repeat the operation till constant weight is obtained.

A-3.2 Calculation

$$\text{Loss on drying, percent by mass} = 100 \times \frac{W_t}{W_{UD}}$$

where

W_t = loss in weight, in g; and

W_{UD} = mass of the undried bentonite taken for test, in g.

A-4 DETERMINATION OF pH VALUE

A-4.1 Procedure

Take 2.0 g of the dried bentonite, add 100 ml of distilled water ($pH = 7.0$) and mix thoroughly. Determine the pH of suspension by means of a suitable pH meter using glass electrode. The test shall be carried out at $27 \pm 2^\circ\text{C}$.

A-4.1.1 Always test distilled water against buffer solution before beginning any pH testing. Distilled water can absorb enough CO_2 from the atmosphere to acidify. Ageing of clays will vary the pH value. The calorimetric method (litmus paper, etc) is not recommended since results cannot be measured precisely.

A-5 DETERMINATION OF LIQUID LIMIT

A-5.1 The liquid limit of a bentonite, determined with the special device, is the water content in a bentonite slurry which will provide enough plasticity to close a prescribed groove in 25 blows.

A-5.2 Procedure

A-5.2.1 Determination of water content (W_2O) of bentonite requiring 20 blows to close the groove — Accurately weigh out of dried bentonite and split in to four approximately equal parts. Thoroughly mix for 90 s a quarter portion (7.5 g) of the bentonite with

exactly 100 ml of distilled water at room temperature in a plastic beaker. Add approximately half of the quarter (3.75 g) and mix for 90 s. Remove any dry bentonite adhering to the beaker well, add to the slurry and remix for 90 s. The consistency of the slurry may be too thin at this stage (indicated by previous experience) and if so, carefully add more bentonite in small amounts to give a suitable consistency, following the prescribed procedure.

Following the 90 s mixing cycle, promptly add the slurry to the cup with a spatula. A good contact between the slurry and the surface of the cup is essential. The amount of slurry required is indicated by the line scribed on the inner surface of the cup. Smooth the slurry until it is level with the line at all points. This step, probably more than any other, will affect the reproducibility of the test. Make a groove with the scribe (*see* Note 1 under A-5.2.3). Remove all the bentonite remaining on the scribe and return it to the beaker. Turn the crank at a rate about 2, counting the blows necessary to close the groove for a distance of 13 cm (*see* Note 2 under A-5.2.3).

If the number of blows is between 1 and 8, carefully add 1 to 3 spatula of bentonite and repeat the 90 s mixing procedure. Then again determine the number of blows needed to close the groove as described above. Note the number of blows it between 9 and 20 and repeat until the number is constant within + 2 blows. Following each sequence, return as much of the slurry as possible to the beaker. Clean the cup with a dampened cloth and dry thoroughly.

After a constant reading of + 2 blows is obtained (in the range of 9 to 20 blows), the weight of remaining unmixed bentonite is determined (*see* Note 3 under A-5.2.3). Subtract this weight from the original 30 g of bentonite to determine the number of grams of bentonite added to the 100 ml of water. This value is 'B' in the equation. Return the slurry into the beaker.

$$W_2O = \frac{W + \frac{P-B}{100}}{B - \frac{P-B}{100}} \times 100$$

where

W_2O = water content for (9 to 20 blows);

W = mass of water used = 100 g;

B = mass of bentonite added, in g; and

P = moisture content of bentonite, in percent.

A-5.2.2 Determination of Water Content of Bentonite Requiring 30-40 Blows to Close the Groove

Carefully add 1 to 3 more spatulas of bentonite to the slurry in the beaker. Experience with the particular

bentonite being testing will indicate the amount required. Repeat the 90 s mixing procedure and determine the number of blows necessary to close the groove as described above. The number of blows required should be in the range of 30-40. Repeat the operation until the number is constant within ± 2 blows and note the number. Determine the weight of bentonite remaining and subtract this weight from the original 30 g of clay to determine the total weight of bentonite added to the water. Determine the water content W_{40} of this more viscous mixture by means of the above equation.

A-5.2.3 Determine the Liquid Limit (W_L)

Plot on semi-logarithmic paper the water content W_{28} and W_{40} against the corresponding number of blows. The number of blows is plotted on the logarithmic scale (ordinate). Connect the two points with a straight line. The point where the axis for 25 blows crosses the line connecting the points W_{28} and W_{40} corresponds to the liquid limit.

NOTES

1 The scribe supports should be adjusted so that the scribe *lightly touches the bottom of the cup, the paper groove being one which exposes the bottom of the cup through-out its length.* Adjustment of the cup to provide the required one centimetre clearance between the bottom of the cup of its highest position and the striking base should be done frequently taking care that the scribe is not off centre this striking the cup unevenly.

2 The closing of the groove shall be taken as the point at which the bottom of the groove joints to cover the exposed portion of the cup for 13 cm along the length of the groove. The groove should not be expected to close entirely, that is along its entire length of its full depth. Only 13 cm closes over so that the cup bottom cannot be seen.

3 By this time, approximately 14 g of the original 30 g have been used.

A-6 GEL FORMATION INDEX

A-6.1 Procedure

Weigh accurately 1.4 g of dried bentonite powder dried to constant weight (at 105°C); 0.2 g magnesium oxide, A.R. quality (dried at 105°C) and 2.6 g of anhydrous alumina, A.R. quality (dried at 105°C) in a stoppered 100 ml measuring cylinder. Dry shake the mixture thoroughly for 5 to 10 min. Add 50 ml of distilled water and shake vigorously for thorough mixing. Add further water to read 100 ml and shake vigorously for 1 hour for the rough mixing. Allow the contents of the measuring cylinder to stand for 24 h. Measure the volume of the supernatant liquid and subtract it from 100 ml. This will give roughly the gel index value of bentonite in percent.

Shaking the mixture thoroughly in a suitable shaking machine for the given time is essential. The shear forces applied while shaking has direct bearing on the

dispersion of bentonite particles. The variation in shaking or thorough mixing and time of mixing gives variations in the results from laboratory to laboratory.

A-7 FREE SWELLING CAPACITY

A-7.1 Procedure

Accurately weigh 2 g of dried bentonite powder (moisture free) and divide the quantity into more than 20 approximately equal parts. Take each part by the tip of a spoon and sprinkle into a graduated cylinder containing 100 ml distilled water ($pH = 7.0$). Care is taken to see that every particle of bentonite is wetted and settled while sprinkled each time till all the 20 parts are over. Generally the time taken for completing the test is 1 to 2 h. The result will be recorded after one hour and after 24 h from completion of test by noting the volume of gel formed.

The free swelling capacity is measured in terms of volume, in ml, of gel formed.

A-8 GELLING TIME

A-8.1 Procedure

Take 10 ml of distilled water in a 2.5 cm dia test tube and add 2.5 g of dried bentonite (dried to constant weight at the temperature of 105-110°C). Shake the mixture well and then add immediately further 15 ml of distilled water. Close the mouth of test tube by rubber cork and shake well. Check the thixotropy of the bentonite by tilting the test tube. Time in minutes after which the bentonite slurry fails to flow ever after keeping test tube in (-) 45° tilted position for 1 min.

A-9 SWELLING INDEX

A-9.1 Procedure

Add 0.2 g, 0.25 g, 0.3 g, 0.35 g, 0.4 g, 0.5 g, 0.6 g, 0.7 g, 0.8 g, 0.9 g and 1.00 g of dried sample of bentonite (moisture free) in different duly marked test tubes of 15 cm dia. Add 10 ml of distilled water in each test tube. Shake the mixture well of each test tube to ensure full dispersion of bentonite. Keep the test tubes for 24 h for full swell. The suspended material with proper ratio will not flow out of the test tube when gently tilted to (-) 45° and shall remain still for at least 1 min. The swelling index is the ratio of water (10 ml) to minimum mass of bentonite (g) at which the suspension just fails to flow.

$$\text{Swelling index} = \frac{100 \text{ ml of water}}{\text{Weight of bentonite (g)}}$$

It is an approximate measure of the limit of hydration.

A-10 CATION EXCHANGE CAPACITY

A-10.1 The methylene blue test measures the active clay present by determining the cation exchange capacity of the bentonite. The number of exchangeable ions present are determined by replacing these ions with methylene blue dye.

A-10.2 Methylene Blue Requirement

A-10.2.1 Procedure

Dry approx 5 g bentonite sample at 105°C for 1 h to the constant weight. Cool it in a desiccator. Take 0.5 g sample from it and mix with 4.5 g of washed graded clayfree absolute silica sand and transfer it in a 250 ml conical flask. Add 50 ml of distilled water and 10 ml of saturated solution of tetra-sodium pyrophosphate ($\text{Na}_4\text{P}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$). Boil the solution for 10 min and cool. Add 1.5 ml of 0.5 N sulphuric acid and shake well for few minutes. Titrate the solution against, standard 0.01 mol/litre methylene blue solution (3.559 g methylene blue per litre of distilled water, if water molecules in MB is 2 or 3.739 g of methylene blue per litre of distilled water if water molecule in methylene blue is 3). After each addition of 1 ml of methylene blue solution, shake the flask and stir the solution for 2 min. By means of glass rod transfer a drop of the suspension on a hardened filter paper to test free MB or a 4 number. Whatman filter paper for visual examination as titration proceeds. The colour of the inner spot will become progressively darker blue as the clay absorbs more and more dye. Eventually the end point of titration will be indicated when the outline of the boundary of the inner blue spot breaks down into a defused light blue hale. As this point is reached, wait for 2 min and repeat the drop test for conformation of end point. The quantity of the methylene blue solution absorbed should conform to the specified value. This gives the value, in ml, of methylene blue solution of a given strength per 0.5 g of the bentonite taken.

A-10.2.2 Preparation of Methylene Blue Solution

The methylene blue should be of pharmaceutical grade or for absorption test purpose USP Grade Merck No. 6040. For each liter or solution carefully weigh 3.739 g of methylene blue crystals (methyl thionine chloride, $\text{C}_{16}\text{M}_{18}\text{N}_3\text{SCL} \cdot 3\text{H}_2\text{O}$ Molecular weight 373.90) on an analytical balance. Using a clean funnel, transfer the crystals to a 1 000 ml volumetric flask. Add approximately 500 ml of distilled water at 40°C, stir for 30 min with a magnetic stirrer. Remove the stirring bar and accurately fill the flask to the 1 000 ml calibration mark with additional distilled water at 40°C. If a magnetic stirrer is not available, mixing can be done in a conventional 1 000 ml beaker where care shall be taken to avoid loss of solution due to splashing

during the process. The solution shall be transferred back to volumetric flask after the first mixing cycle for the accurate addition of distilled water to the 1 000 ml level.

Transfer the solution to dark brown glass bottles for storage and allow to stand for 12 h before use.

A-10.3 Calculations

A-10.3.1 Methyl Blue Requirement, in mg

After the titration the MB requirement in ml should be converted to mg of MB 1 g of bentonite.

$$\text{Mg of MB/g of bentonite} = 2 \times \text{ml} \times \text{MBW}$$

where MBW is mass of MB/litre of distilled water (3.739 g where MB has 3 water molecules, or 3.559 g where MB has 2 water molecules)

MB, in ml, is multiplied by 2 because titration is done taking 0.5 g of bentonite hence to convert it to per g it shall be multiplied by 2.

A-10.3.2 Cation Exchange Capacity in meg of MB/ 100 g of Bentonite

MB solution shall be of strength where 1 ml = 0.01 meg or 1 mm 01. That is MB solution have 3.739 g of MB/litre of distilled water of 3.539 g of MB/litre of distilled water. Titration from this solution shall give results convertible to any unit for reporting.

$$X, \text{ ml} = \frac{X \text{ meg}}{100 \text{ g}} = \frac{3.739 X \text{ mg}}{\text{g}}$$

where X is the consumption of MB, in ml.

The numerator is representing methylene blue dye, in ml, of meg or mg and denominator is bentonite, in g, or 100 g.

A-11 CONE FUSION TEMPERATURE AND SINTERING TEMPERATURE

A-11.1 Cone Fusion Temperature

The sample should be fused and bloated with 'NO SHRINKAGE' after heating at 1 300°C for 15 min.

A-11.1.1 Procedure

Fill a fireclay combustion boat of approximate dimensions 45 mm × 15 mm × 5 mm deep with the bentonite and strike off level. Place in a furnace at 1 300°C for 15 min, remove and note the condition of the bentonite after cooling.

A-11.2 Sintering Range

A-11.2.1 Procedure

The sample of bentonite is loosely packed a combustion

boat and kept in the hot zone of electric tube furnace. The boat containing the sample of bentonite is kept in the furnace for a minimum time of 3 to 5 min. The experiment is started at a temperature of 800°C and continued with subsequent increments of 50°C till sintering occurs. After 4 min in the furnace the specimen is taken out, cooled to room temperature and visually examined whether sintered or not.

A-12 BONDING PROPERTIES

A-12.1 Procedure

A-12.1.1 Standard Sand Mix Test

Mix 5 kg of standard silica sand for raw material testing in foundries (*see* IS 3018) with 7 percent bentonite from composite sample). Dry mix for 3 min in a laboratory sand mixer, and then add 4.5 percent of water and mix for another 5 min. Collect the mixture in a polyethylene bag and test for green compressive strength and green shearing strength on a standard 50.8 × 50.8 mm – 3 ram test piece. The results of test pieces thus made from mixture of silica sand bonded with subject bentonite shall be compared with the reference bentonite. The test result should be acceptable as per standard values.

A-13 CHEMICAL COMPOSITION

A-13.1 Representative samples are chemically analysed by supplier adopting standard methods for SiO₂, Al₂O₃, Fe₂O₃, FeO, MgO, CaO, K₂O, Na₂O and TiO₂. Results of the chemical analysis furnish preliminary information of contamination and abnormal substitutions in the lattice. Chemical composition is to be mentioned on test certificate by the supplier specifically.

A-13.2 Na₂O + K₂O in percent by weight is to be mentioned on the test certificate.

A-13.3 Ratio of Na₂O/CaO by weight is to be specifically mentioned on the test certificate.

A-13.4 Determination of Calcium Oxide Content (Replaceable Ca).

A-13.4.1 Reagents

A-13.4.1.1 Benzyl trimethyl ammonium chloride solution—6 percent (w/v)

A-13.4.1.2 Dilute hydrochloric acid — 1:1 (v/v).

A-13.4.1.3 Ammonium hydroxide — 20 percent NH₃ (w/w).

A-13.4.1.4 Ammonium oxalate solution—Dissolve 4 g of the ammonium oxalate in 100 ml of water.

A-13.4.1.5 Dilute sulphuric acid — 1:19 (v/v).

A-13.4.1.6 Standard potassium permanganate solution, 0.05 N.

A-13.4.2 Procedure

Weight 10 g of the dried material into a 250 ml beaker and add 100 ml of benzyltrimethyl ammonium chloride solution and mix by moderate speed stirrer for 4 min. Wash the stirrer with cold water in the beaker. Filter over a Whatman No. 1 or No. 30 filter paper. Wash the beaker, residue and the paper with cold water to remove the traces of the stripping reagent. Acidify the benzyltrimethyl ammonium chloride filtrate with several millilitre of dilute hydrochloric acid and evaporate to a volume of about 250 ml. Heat incipient boiling and add 25 ml of ammonium oxalate solution and ammonium hydroxide until slightly alkaline. Stir thoroughly and allow the precipitate to settle out, keeping the solution warm for 3 h to 4 h but not boiling. Filter and wash five times with cold water. Dissolve the washed oxalate precipitate in 50 ml of dilute hydrochloric acid, dilute to about 150 ml and the paper with cold water until ammonium oxalate is removed. Avoid excessive washing. To the beaker used for the precipitation, add 150 ml of dilute sulphuric acid (1:19) then introduce the paper containing the precipitate. Heat to almost boiling and titrate with standard potassium permanganate solution. A blank shall be previously determined for the effect of the paper.

A-13.4.3 Calculation

$$\text{Calcium oxide, percent} = \frac{(V - V_1) \times N \times 0.028 \times 100}{W}$$

where

V = volume of the standard potassium permanganate solution used, in ml;

V_1 = volume of the standard potassium permanganate solution used for the blank, in ml;

N = normality of the standard potassium permanganate solution; and

W = mass of the material taken for the test, in g.

A-13.4.4. Na⁺/Ca⁺⁺ Ratio

The Na⁺/Ca⁺⁺ ratio is found out by a flame photometer and the results are mentioned on the test certificate. The total exchangeable cations is also mentioned on the certificate.

A-14 LOSS ON IGNITION (LOI)

A-14.1 Procedure

Weigh accurately about 2 g of the dried material in a previously ignited and tared silica crucible. Heat very gently until bubbles cease. Continue the ignition in a

muffle furnace at red heat for 1 h cool the desicator and weigh. Repeat the operation till constant weight is obtained.

A-14.2 Calculation

Loss of ignition (LOI),
percent by mass $= 100 \times \frac{W_2 - W_3}{W_2 - W_1}$

where

- W_1 = mass of the empty crucible, in g;
- W_2 = mass of the crucible with the material before ignition, in g; and
- W_3 = mass of the crucible with the material after ignition, in g.

Approximately Cation Exchange Capacity and Percentage of Montmorillonite

<i>mg of MB/g of Bentonite</i>	<i>meg/100 g of Bentonite</i>	<i>Percent Montmorillonite Bentonite</i>
220	58.84	40.74
230	61.51	42.59
240	64.18	44.44
250	66.86	46.29
260	69.54	48.15
270	72.21	50.00
280	74.89	51.85

<i>mg of MB/g of Bentonite</i>	<i>meg/100 g of Bentonite</i>	<i>Percent Montmorillonite Bentonite</i>
290	77.56	53.70
300	80.24	55.55
320	85.58	59.26
330	88.25	61.11
340	90.93	62.96
350	93.64	64.82
360	96.28	66.67
370	98.95	68.52
380	101.63	70.37
390	104.31	72.22
400	106.98	74.07
410	109.65	75.93
420	112.32	77.78
430	115.00	79.62
440	117.68	81.48
450	120.35	83.33
460	123.02	85.19
470	125.70	87.08
480	128.38	88.89
490	131.05	90.74
500	133.73	92.59
510	136.40	94.44
520	139.07	96.30
530	141.75	98.15
540	144.42	100.00

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This Indian Standard has been developed from Doc : No. MTD 14 (4604)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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