STEEL FOUNDERS' SOCIETY OF AMERICA

Tentative Specification for

WESTERN BENTONITE

SFSA Designation: 13T - 86

ISSUED: 1986

Superseding 13T-65, Issued 1965

This Tentative Specification has been approved by the Society's Specification Committee. The Tentative Specification shall be in effect for two (2) years and, if not revised in that time, it shall be advanced to Standard. Suggestions for revisions should be addressed to the Steel Founders' Society at Cast Metals Federation Building, 455 State Street, Des Plaines, Illinois 60016.

1. Scope

1.1 This specification covers western bentonite (see Note 1) which is used either as a binder in mold and core sand or in the preparation of core and mold washes.

NOTE 1. Western Bentonite as applied to this specification is composed chiefly of the minerals of the Montmorillonite family in which the ratio of sodium ion to calcium ion in the base exchange is approximately 1.7 to 1.

2. Ordering Information

2.1 Orders for material under this specification shall include the following information:

2.1.1 Quantity

2.1.2 Name of material

2.1.3 This specification number

2.1.4 Requirements for packaging, analysis, reports, etc. as appropriate

2.2 When specified a vendor shall indicate this specification number in all quotations and when acknowledging purchase orders.

3. Quality

3.1 The material shall be of uniform composition and free from foreign materials.

3.2 The material shall be free from adulterants, with any added material reported to the foundry.

4. Sample Preparation

4.1 The number of bags to be sampled in routine testing of carload shipments shall be 10 which shall be selected at random.

4.1.1 The sample shall be reduced by quartering until a 2.5-pound sample is obtained.

4.1.2 An alternate method for reducing the gross sample is by the use of a sample splitter which is described in the AFS "Mold and Core Test Handbook", 1st Edition, Section 2.

4.1.3 Identification of sample shall indicate material, producer, supplier, source of shipment and date shipment was received.

4.2 In case of a dispute between supplier and purchaser, the number of bags to be sampled shall be according to ASTM C-322, Procedure C.

4.2.1 The numbers of samples shall depend on rhe number of units in shipment. A grain sampler or similar sampling instrument shall be used to take samples which shall then be combined, mixed and quartered or riffled to obtain a 2.5-pound laboratory sample.

4.2.2 When a shipment consists of less than 500 bags but greater than 100 bags, the number of bags sampled shall be not less than 15. For lots of 500 to 1000 bags, 20 bags shall be sampled.

5. Technical Requirements

5.1 Moisture

5.1.1 The maximum water content shall not exceed 11 percent and the minimum content shall not be less than 6 percent.

5.2 The pH value

5.2.1 The pH value shall be equal to or greater than 8.2.

5.3 Green Compression

5.3.1 The green compressive strength shall be a minimum of 15 psi @ 46-5 1% compactibility for a 7% bentonite - 2.3 -2.6% water-sand mix.

5.4 Methylene Blue

5.4.1 The methylene blue test shall have a minimum of 90 ml of uptake for a 1 gram of the material.

6. Packaging or Bagging

6.1 Packaging shall be accomplished in such a manner as to insure against loss of material as well as exposure to moisture.

6.2 The bentonite shall be packaged in heavy duty bags which hold a maximum of 105 pounds.

6.3 Each container (bag) shall be legibly marked with the following:

6.3.1 "Western Bentonite" and trade name in a color contrasting to that of the bag.

6.3.2 Quantity of weight (contained).

6.3.3 Producer's name.

7. Inspection

7.1 The vendor shall afford the inspector representing the foundry all reasonable facilities, without charge, to satisfy him that the material is being furnished in accordance with this specification.

8. Rejection

8.1 Bentonite ordered to this specification that does not conform to the requirements of this specification will be subject to rejection by the foundry.

Supplementary Requirements

Supplementary requirements shall only apply when specified by the foundry. Details of the supplementary requirements shall be agreed on by the vendor and foundry.

S. 1 The material shall be free from any additions, other than water, made to conform the material to the specification.

S.2 Each bag shall he sampled.

S.3 Calcium oxide content

S.3.1 The calcium oxide content shall not exceed 0.70 percent (25 milliequivalents of Ca/100 grams of bentonite).

S.4 Liquid Limit

S.4.1 The liquid limit shall he not less than 600 or greater than 850.

S.5 Bulk Density

S.5.1 The maximum variation in the hulk density of a bentonite furnished a foundry by a producer shall not be greater than ±50 grams per quart of the specified average bulk density.

S.5.2 The specified average hulk density in grams per quart shall he established by mutual agreement between the vendor and the foundry.

Note 2.The hulk density of bentonite is only significant to those foundries that measure bentonite additions by volume.

S.6 Viscosity

S.6.1 The material shall pass a viscosity test. The procedure and values shall he agreed on by the vendor and foundry.

S.7 Certification

S.7.1 The vendor shall submit to the foundry a certified report of the test results together with a statement that all the requirements of this specification have been met.

S.8 Screen Analysis

S.8.1 The vendor shall submit to the foundry a copy of the screen analysis relative to the grind requested by the foundry.

ANNEX I

Acceptance Tests

1. Moisture (mechanically held)

1.1 Weigh quantitatively (to second decimal) 10 grams of hentonite into a dried, weighed crucible. Spread uniformly over the bottom of the crucible. Place the crucible and bentonite into a drying oven. Heat for two hours at 105-110 degrees centigrade (220-230 degrees F); cool in a desiccator and weigh.

1.2 Calculations

1.2.1 Percent Moisture =

$$\frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

2. The pH value

2.1 Determination of the pH value of Western Bentonite (see Note 3).

*2.1.1 To determine pH every 30 seconds until the results are constant.

2.1.2 The pH should he determined by electrometric methods.

NOTE 3. In the determination of pH, neutral water (approximately 7.0 pH) should be used.

3. Green Compression Test

3.1 Sample preparation

3.1.1 Mull 93% round grain, 4 screen 56-62 average grain fineness sand and approximately 2.3% added water. With a vertical wheel laboratory muller sand and water should be mulled one minute. The amount of water added should be sufficient to achieve a compatiblity of 46-51%. After adding the 7% Bentonite (as received) mull 8 minutes and test.

If a horizontal wheel muller is used, mull 20 seconds with water and 3 minutes with Bentonite.

3.2.1 The compression test shall he conducted in accordance with the procedure described in the AFS "Mold and Core Test Handbook", First Edition, Chapter 11.8.

4. The Methylene Blue Test

4.1 The Methylene Blue Test shall he conducted in accordance with the procedure described in the AFS "Mold and Core Test Handbook", First Edition, Section 17.

5. Calcium Oxide Content

5.1 Procedure by the Versene Method (see Note 4).

5.1.1 Prepare a standard 6 percent solution of benzyltrimethyl ammonium chloride by diluting 30 ml of the salt with 470 ml of distilled water (see Note 5). The standard solution may also he prepared from dilution of commercially available solutions.

5.1.2 Weigh out 10.00 grams of dried bentonite, using a balance sensitive to 10 milligrams. Add the bentonite to exactly 100.0 ml of the standard 6 percent solution of benzyltrimethyl ammonium chloride and mix at moderate speed in a Hamilton Beach or similar mixing equipment for a period of 4 minutes. Filter, using either a Whatman No. 30 or similar filter paper. Save the filtrate.

5.1.3 Dilute 2.0 ml of the filtrate to approximately 50 ml with distilled water. Add 2 ml of sodium hydroxide solution (see Note 6). Then add murexide indicator (about 1/10 gram). The nature of the color change from pink to purple causes wide variations in the quantity of indicator used by individuals (see Note 7).

5.1.4 Titrate with standard Versenate solution (see Note 8). At the end point the color changes from pink to purple.

5.1.5 Note ml of the versenate solution required to titrate sample.

5.1.6 Calculation

Me of Ca ion/100 grams of bentonite = 10 x (ml titrant).
% CaO = (me of Ca/ 100 grams of bcntonitc) x (0.02804).

* To 100 ml PH7.0 distilled water in a 200 ml beaker add 6 to 8 grams of bentonite and mix thoroughly.

NOTE 4. Briefly, the method consists of washing the soluble and exchangeable salts and ions from the bentonite by means of a stripping agent, then determining the calcium content by direct titration with a standard versene solution in the presence of a buffer and a calcium indicator. Water hardness test kit may be used. These may be purchased from Nalco Chemical Company, 6216 West 66th Place, Chicago, IL 60638, or W.A. Taylor and Company, 7300 York Road, Baltimore, MD 21212.

NOTE 5. Benzyltrimethyl ammonium chloride is a powerful quaternary ammonium salt for removing water soluble salts from bentonite. It is manufactured by Commercial Solvents Company, Terre Haute, Indiana. Make 6 percent solution of the salt as received, which is approximately a 60 percent solution.

NOTE 6. Sodium hydroxide solution. Dissolve 40 grams of sodium hydroxide in water and dilute to 1 liter.

NOTE 7. The correct amount of the calcium indicator must be determined by each operator in a trial determination. If 1/10 gram does not give a sharp end point, repeat from 7.3.1.2 and increase amount of calcium indicator slightly. Solution should be slightly pink after adding indicator. Better calcium indicator color change purple — blue better visibility on color change "Hydroxy Naphthol Blue" from Aldrich Chemical Co. Cat. No. 21-991-6.

NOTE 8. Standard versene solution is 0.02 N or N/50. May be purchased from W.A. Taylor and Company, Reagent No. 618 or Nalco Chemical Company — Solution No. H-1 or Nalco Salution No. 274.

6. Liquid Limit Test

6.1 Apparatus

6.1.1 Balance: Any suitable balance accurate to 0.0 1 grams.

6.1.2 Aluminum Moisture Dish: Aluminum foil with a flat bottom and a small table on the top edge for handling. Diameter 58 mm. Depth 18 mm. May be obtained from any chemical supply house.

6.1.3 SFSA Approved Standard Liquid Limit Test Equipment: Includes specially equipped mixer, blade, dispersing jar and lid, spatula, and device for measuring the consistency of a bentonitc-water slurry. This equipment may be obtained from Soiltest Incorporated, 2205 Lee Street, Evanston, Illinois 60202.

6.1.4 Desiccator: Any suitable size loaded with indicating Drierite and a small dish of phosphoric anhydride.

6.1.5 Drying Oven: Capable of being maintained at 105-110 degrees C.

6.1.6 Liquid Limit Data and Computation Sheet:

6.1.7 Evaporating Dish: Low form, porcelain, glazed inside, 50 ml capacity 80 mm diameter, 20 mm height. May he obtained from any chemical supply house.

6.2 Reagents

6.2.1 Distilled water, carbonate free.

6.3 Procedure for determining moisture in bentonite.

6.3.1 Weigh, on a balance sensitive to 1.0 milligrams, 10.00 grams of hentonite in a tared aluminum dish. Place the container with the bentonite in a drying oven at 105-I 10 degrees C for 2 hours (see Note 9). Remove the container from the furnace, cool in a disiccator; weigh and determine the percent moisture in the bentonite (see 1.2.1 for method of calculating percent moisture).

NOTE 9. A more rapid, but probably slightly less accurate, method of determining the moisture in the bentonite employs a Temco non-circulating muffle furnace for fast drying. Place the weighed sample of bentonite into the muffle furnace at 300 degrees C for 15 minutes. Remove bentonite from furnace, cool in a desiccator, weigh and determine percent moisture (see 1.2).

The high drying temperature will remove some absorbed water; therefore, the bentonite is not dried to constant weight nor should the drying time exceed the 15-minute time limit.

6.4 Determination of water content of bentonite requiring less than 20 blows to close the groove.

6.4.1 Begin the liquid limit determination by weighing on a balance sensitive to 10 milligrams, 30 grams of bentonitc in a container (aluminum cup). Spread to a uniform depth and mark in approximately four equal parts.

6.4.2 Add exactly 100 ml of distilled water (see Note 10) (pH 7.0 is recommended) to the dispersing jar. Then add ¼ the bentonite weighed in step 6.4.1 to the dispersing jar and adjust the propeller so that the bentonite will he pushed to the middle of the jar.

6.4.3 Start motor, move the closed jar up and down on the mixing shaft until the hentonitc is thoroughly disperses (90 seconds). Add approximately ½ of the second ¼ of the bentonite to the dispersing jar and again mix by moving the closed jar up and down on the shaft for 90 seconds.

6.4.4 The jar should he removed from the mixer and the sides scraped with a spatula to insure that there is no dry bentonite adhering there. Mix the slurry again for 90 seconds, according to the procedure previously described. Experience will soon develop one's ability to know if the mixture is too thin to make a groove in the cup of the liquid limit apparatus. If the mixture is too thin, thicken by adding a spatula or more of bentonite to the mixture (see Note 11). Again follow the prescribed mixing procedure.

NOTE 10. The temperature of the water should be maintained constant.

NOTE 11. Bentonite must be added carefully to the dispersing jar so as not to spill any of the bentonite

6.4.5 Following the 90-second 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 very essential. The amount of slurry required is indicated by a 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. Particular emphasis must be given to the uniformity of execution of this operation.

6.4.6 Make a groove with the srriher (see Note 12). Remove all the hentonite remaining on the scriber and return it to the jar. Carefully remove the rubber mat underneath the cup and turn the crank at a rate of about two revolutions per second; count the blows necessary to close the groove for a distance of ½ inch (see Note 13).

6.4.7 If the number of blows is between 1 and 8, carefully add 1 to 3 spatulas of bentonite and repeat

the 90-second mixing procedure. Then again determine the number of blows needed to close the groove as described in 6.4.5 through 6.4.6.

NOTE 12. The scriber supports may not be properly aligned when the device (6.1.3) is received and should be adjusted so that the scriber lightly touches the bottom of the cup when the rubber mat is in place under the cup. The proper groove is one which exposes the bottom of the cup throughout its length. The rubber mat should be under the cup during the scribing operation, to provide a cushion for the protection of the cup from severe scratching if the scriber strikes it too heavily.

Adjustment of the cup to provide the required one centimeter clearance between the bottom of the cup at its highest position and the striking base should he done frequently. This adjustment may position the cup in such a way that the scriber is off-center and thus strikes the cup unevenly. In such a case, the scriber supports must he adjusted so that the cup is lightly scraped clean the entire length of the groove. The suhsequcnt determination of the closing of the groove is made more reproducible if it has been properly scribed.

NOTE 13. The closing of the groove must be taken as the point at which the bottom of the groove joins to cover the exposed portion of the cup for ½ inch along the length of the groove. The groove should not be expected to close entirely, i.e., along its entire length or its full depth; only ½ inch closes over so that the pan bottom cannot be seen.

6.4.8 If the number of blows is between 9 and 20, repeat 6.4.5 through 6.4.6 until the number of blows is within ±2 blows of the previous trials. Following each sequence, return as much of the slurry as possible to the dispersing jar. Clean the cup with a dampened cloth and dry thoroughly.

6.4.9 After a constant reading of ±2 blows is obtained (in the range of Y to 20 blows), the weight of the remaining unmixed bentonite is determined (see Note 14). Subtract this weight from the original 30 grams of hentonite to determine the number of grams of bentonite added to the 100 ml of water. This value is B in equation (1).

6.4.10 Return slurry to the dispensing jar.

6.4.11 The water content (see Note 15) of the mixture may he expressed in the following word formula:

$$\text{Water Content} = \frac{\text{g of water added plus g of water in the benronite added}}{\text{g of bentonite minus g of water in the bentonite added}} \times 100$$

The grams of water in the added bentonite are determined by multiplying the percent water in the bentonite (determined in 6.3) by weight of bentonite added (determined by 6.4.9). The resultant product is divided hv 100.

NOTE 14. By this time, approximately 14 grams of the original 30 grams weighed in step 6.4.1 have been used.

NOTE 15. The water content as defined by soil engineers is the weight of the water in the bentonite-water slurry divided by the weight of the bentonite added to the slurry, times 100. The liquid limit of a bentonite is based on the dry weight of the bentonite.

6.5 Calculation of W_{20} water content

6.5.1 $$W_{20} = \frac{W + \frac{PB}{100}}{B - \frac{PB}{100}} \times 100 \quad \text{Eq (1)}$$

where W_{20} = Water content for approximately Y to 20 blows

W = grams of water added

B = grams of bentonite added

P = percent moisture in the bentonite added

6.5.2 Example:

Grams of water added	100
Percent moisture in bentonite	9.1
Grams of bentonite added (30-16)	14.0

$$W_{20} = \frac{100 + \frac{9.1 \times 14}{100}}{14 - \frac{9.1 \times 14}{100}} \times 100$$

$$= \frac{100 + 1.27}{14 - 1.27} \times 100$$

$$= \frac{101.27}{12.73} \times 100 = 796$$

6.6 Determination of water content of hentonitc requiring between 30-40 blows to close the groove.

6.6.1 Carefully add 1 to 3 more spatulas of hentonitc to the slurry in the dispersing jar. Experience with the particular bentonite being tested will dictate the amount of addition required.

6.6.2 Repeat the 90-second mixing procedure and determine the number of blows necessary to close the groove as described in 6.4.5 through 6.4.6. The number of blows required should he in the range of 30-40. Repeat the operation until the numher of blows is within ±2 blows of the preceding trial.

6.6.3 Determine the weight of bentonite remaining after completing 6.6.1. Subtract this weight from the original 30 grams of clay to determine the total grams of hentonite added to the water.

6.7 Calculation of W_{40} water content.

6.7.1 Determine the water content of this more viscous mixture by the method outlined in part 6.3.

6.7.2 Example:

Grams of water added	100
Percent moisture in bentonite	9.1
Grams of bentonite added (30-5.2)	24.8

6.7.3 Water content W_{40} is calculated as outlined in 6.5 by substituting 24.8 for 14. W_{40} = 454.

6.8.2 Example: Let it he assumed that 15 blows were required to close the groove in step 6.4.8 and 35 blows in step 6.6.2. The water content of the slurry requiring 15 blows to close the groove was 796, and at 35 blows 454. A plot of the water content against log of blows is shown in Figure 1. The two points are connected by a straight line. The liquid limit (W_L) is read as the water content at twenty-five blows. In the plot in Figure 1, the liquid limit is 590.

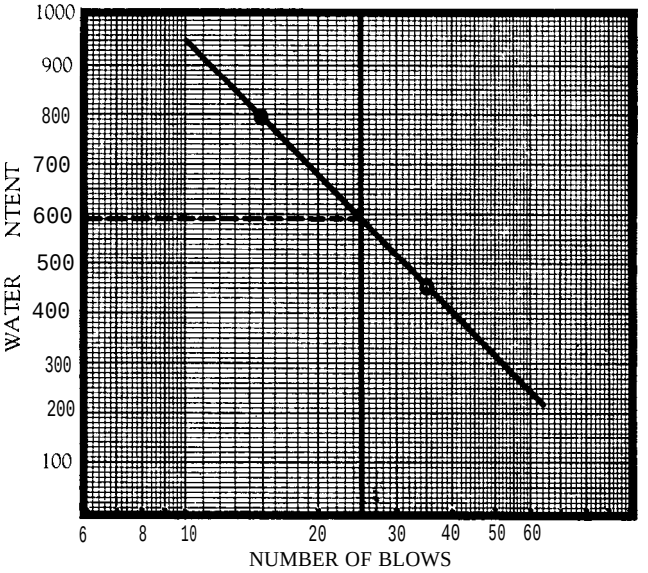

Figure 1. Graphic determination of the liquid limit (W_L) of bentonite. (Liquid limit data and computation sheets may be purchased from the Steel Founders' Society in pads of 25 sheets.)

7. Procedure for determining bulk density

7.1 Equipment

7.1.1 Cast iron laboratory tripod, one ring single grooved, 6" nominal size, 6⅝" outside dimensions, 4 3/8" inside dimensions and 1/8" thickness. Three legs 5/16" diameter, 9" long (tripod mounted).

7.1.2 Flour sifter (Washburn Company, Rockford, Illinois, Antrock No. 573X). Consisting of three 18-mesh screens with squeeze handle sift mechanism.

7.1.3 A standard Ohaus one quart dry measure container — 4 7/16" inside diameter and 4 7/16" high. May be purchased from any laboratory equipment dealer who handles Ohaus scales.

7.2 Procedure

7.2.1 Select a representative sample of the material to be tested. The amount of the material should he approximately one gallon dry measure. Assemble the apparatus so that the tripod is on a parallel surface with the quart measuring container directly underneath the ring stand. Place on the top of the ring stand, the flour sifter.

7.2.2 Slowly add portions of the material to be tested to the flour sifter. Sift and collect the material to be tested in the quart measuring vessel. When the quart container is overflowing, stop sifting. Remove the flour sifter and ring stand (see Note 16).

Strike off immediately and carefully the bentonite above the quart measure container with a one-inch strike-off ruler.

7.2.4 Empty the bentonite from the quart container on a scale which has a gram accuracy. Determine the weight of the bentonite in grams. This gives the bulk density in grams per quart.

7.2.5 Repeat test with a different sample.

7.2.6 Average the two tests, and this value is parent bulk density.

NOTE 16. Extreme care should be taken in using the flour sifter, so as not to move or disturb the quart measuring container below.