

Australian Standard®

AS 1141.24:2018

Methods for sampling and testing aggregates Method 24: Aggregate soundness—Evaluation by exposure to sodium sulfate solution

PREFACE

This Standard was prepared by Standards Australia Committee CE-012, Aggregates and Rock for Engineering Purposes, to supersede AS 1141.24—2013.

IMPORTANT COPYRIGHT INFORMATION

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- (1) Clause 7(c) Containers (modified).
- (2) Note to Clause 9.
- (3) Note to Clause 9(a) (modified).

A copy of the complete ASTM Standard may be obtained from ASTM International, www.astm.org

1 SCOPE

This Standard sets out the method for testing aggregates to determine the loss of mass due to disintegration when exposed to sodium sulfate solutions over repeated cycles of wetting and drying.

The Standard furnishes information helpful in judging the soundness of aggregate subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

2 APPLICATION

The values obtained from this method may be used for comparison in specifications, e.g. AS 2758.1 and AS 2758.2. Since the precision of this test is poor in both repeatability and reproducibility, it may not be suitable for the outright rejection of aggregates without confirmation from other tests more closely related to the specific intended use.

Values for permitted percent loss by this method for fine aggregates may be different to those for coarse aggregates.

This Standard requires the method specified in AS 1141.11.1 to be performed during preparation of the test portions.

3 PRINCIPLE

This test method is designed to assess the resistance of the rock fabric to salt crystallization pressure, which is a measure of the susceptibility of the rock to physical breakdown. The extent of this breakdown is assessed by repeated immersion of the aggregate in a saturated solution of sodium sulfate followed by oven drying to dehydrate the salt precipitated in permeable pores and rehydration of the salt during subsequent immersion, which generates crystallization pressure. Internal expansive forces, derived from rehydration of the salt on re-immersion, mimic freezing (crystallization of water) or salt action. This provides a measure of the integrity of the rock fabric when subjected to physical weathering associated with the expansion on freezing of water in aggregate pores, and the expansion of salts on rehydration in marine conditions following repeated wetting and drying.

4 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

AS

1141	Methods for sampling and testing aggregates
1141.1	Part 1: Definitions
1141.2	Method 2: Basic testing equipment
1141.3.1	Method 3.1: Sampling—Aggregates
1141.3.2	Method 3.2: Sampling—Rock spalls and boulders
1141.11.1	Method 11.1: Particle size distribution—Sieving method

ISO

649	Laboratory glassware—Density hydrometers for general purposes
649-1	Part 1 Specification

5 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 1141.1 and those below apply.

5.1 Mixed aggregate

An aggregate with more than 5% by mass retained on a 4.75 mm sieve and with more than 5% passing a 4.75 mm sieve.

5.2 Separating sieve

A sieve, as defined in Tables 3 and 4, used to determine the loss.

6 REAGENTS

The following reagents are required:

- (a) Anhydrous or decahydrate sodium sulfate (Na_2SO_4) technical grade.
- (b) Barium chloride (BaCl_2) technical grade.
- (c) Potable water.

7 APPARATUS

The following apparatus, conforming with the relevant provisions of AS 1141.2 is required:

- (a) *Balance*—with a capacity of not less than 5 kg and a limit of performance not exceeding ± 0.5 g.
- (b) *Bath (constant temperature)*—of material that is resistant to the corrosive effects of solutions of sodium sulfate. Alternatively, a commercially available bath may be used, with an inserted bath of corrosion-resistant material, or of a material that is considered expendable. The bath shall operate in such a manner that the temperature of the sodium sulfate solution is maintained at $23 \pm 1^\circ\text{C}$ at any point in the area of the bath containing the solution at a depth not less than 75 mm below the surface of the solution. The bath shall be cleaned out every three weeks during use if no liner is used.

NOTE: The success of this method is critically dependent on exposure of the aggregate to a saturated solution of sodium sulfate at all times. The solubility of sodium sulfate is temperature dependent around the specified operating temperature of the bath. In some locations in Australia, baths may require both heating and refrigeration controls to maintain operation within specification. Records of bath operating temperature over time should be maintained at least until constant temperature operation can be demonstrated.

- (c) *Containers*—for immersing the samples of aggregate in the solution. Containers shall be perforated in such a manner as to permit free access of the solution to the sample and drainage of the solution from the sample without loss of aggregate. For any aggregate fraction size, at no time shall the perforations in the container used for that fraction exceed the opening of the sieve used to determine the loss for that fraction (see Tables 3 and 4).

NOTE: See Preface for copyright information about this Clause.

- (d) *Hydrometer(s)*—20/L20 hydrometers conforming to the requirements of ISO 649-1 and capable of measuring solution density within the range of at least 1.155 g/mL to 1.170 g/mL with an accuracy of ± 0.001 g/mL.
- (e) *Evaporation oven*—capable of operating between 105°C – 110°C , and with an average evaporation rate of 25 g/h over a four hour period from each beaker in the oven, when tested in accordance with the following procedures. In all other respects, the oven shall conform to the requirements of AS 1141.2, as follows:
 - (i) Each shelf of the oven intended to be part of the working space of the oven shall be tested at the same time.
 - (ii) Each shelf shall be charged with five 1 L glass beakers, one in each corner of the shelf, and one placed in the centre of the shelf. All beakers shall contain 500 g of water, initially at a temperature of $23^\circ\text{C} \pm 2^\circ\text{C}$.
 - (iii) At the commencement of the test, the oven shall be empty and operating between 105°C – 110°C .
 - (iv) The beakers shall be placed in the oven as quickly as possible and the oven door shall then remain closed for the four-hour duration of the evaporation test.
 - (v) The evaporation rate shall be determined by the weight loss of each beaker.
 - (vi) Any shelf of the oven shall only be assessed as conforming to the evaporation requirements if each beaker on the shelf records a minimum loss of 100g.
- (f) *Sieves*—in square perforated plate or square woven wire in sizes 75 mm, 53 mm, 37.5 mm, 26.5 mm, 19.0 mm, 16.0 mm, 13.2 mm, 9.50 mm, 8.00 mm, 6.70 mm, 4.75 mm, 3.35 mm, 2.36 mm, 1.70 mm, 1.18 mm, 850 μm , 600 μm , 425 μm , 300 μm , and 212 μm .

- (g) *Thermometer*—or other suitable temperature measuring device capable of measuring the temperature of the solution within the range of 20°C to 30°C graduated to 0.1°C or less.

8 SAMPLING

Aggregate samples to be used in the preparation of sample fractions to be tested shall be obtained in accordance with the procedures described in AS 1141.3.1 and AS 1141.3.2.

9 PREPARATION OF SATURATED SODIUM SULFATE SOLUTION

A fresh solution of sodium sulfate is required for each test. Used solution shall be discarded at the completion of each test.

NOTES:

- 1 Some aggregates containing carbonates of calcium or magnesium are attacked chemically by fresh sulfate solution resulting in erroneously high measured losses. If this condition is encountered or is suspected, the test should be repeated using a filtered solution that has been used previously to test the same type of carbonate rock, provided the solution meets the requirements for solution density given in this Clause.
- 2 See Preface for copyright information about this Clause.

The procedure for preparation of the solution shall be as follows:

- (a) Dissolve sufficient technical grade anhydrous sodium sulfate (Na_2SO_4) or technical grade decahydrate sodium sulfate ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) in clear potable water to produce a saturated solution at 23°C. The mixture may be heated to between 25°C and 30°C and stirred to aid in dissolving the salts. Prepare sufficient solution to exceed at least five times the solid volume of the aggregate to be tested.

NOTES:

- 1 Anhydrous sodium sulfate (Na_2SO_4) and decahydrate sodium sulfate ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) are slightly unstable in water and accordingly it is recommended that more than the minimum salt required to achieve saturation is added to create an excess of salt crystals in the solution. Between 235 g and 250 g of the anhydrous salt (compared with 215 g that can be calculated to achieve saturation) or 760 g of the decahydrate sodium sulfate (compared with 700 g that can be calculated to achieve saturation) should be used.
 - 2 See Preface for copyright information about this Clause.
- (b) When no more salt appears to be entering the solution, allow the solution to cool to 23°C ± 1°C. Stir the solution regularly during cooling.
- (c) Allow the solution to stand at 23°C ± 1°C for at least 24 h.
- (d) Measure and record the density of the solution at 23°C ± 1°C using the 20/20 hydrometer.
- (e) If the density of the solution is above 1.170 g/mL, add sufficient water to reduce the density to the required range. Add the water in small quantities followed by vigorous stirring. Allow the solution to stand at 23°C ± 1°C for at least 2 h before the final density determination is made.
- (f) If the density of the solution is below 1.155 g/mL, add salt and bring into solution by heating and stirring. Allow the solution to stand at 23°C ± 1°C for at least 4 h before the final density determination is made.
- (g) If any cloudiness is apparent, filter the solution. Discard the solution if it is unduly discoloured.
- (h) If the solution is prepared more than a day prior to use, store it in a sealed or stoppered container to prevent evaporation.

10 PREPARATION OF TEST FRACTIONS

The procedure for preparation of the test fraction shall be as follows:

- (a) Obtain by riffing or quartering the sample, a representative test portion of sufficient size to perform a particle size distribution and perform that test in accordance with AS 1141.11.1.

NOTE: This test portion may be used for the soundness test if it has not broken down during the particle size distribution.

- (b) By sieving the sample remove those fractions which represent less than 5% by mass of the test portion as determined in Step (a).
- (c) Ensure that each of the retained test fractions exceeds the minimum mass for the fraction size as given in Tables 1 and 2, as applicable.
- (d) Thoroughly wash the test portion obtained over the smallest retained sieve, that is 4.75 mm sieve for coarse aggregate and 300 μm sieve for fine and mixed aggregates. Dry the washed test portion to constant mass in a drying oven at 105°C to 110°C.
- (e) Separate the test portion into as many of the fractions shown in Tables 1 and 2 as are present. Recalculate the original particle size distribution so that the retained fractions are considered as representing the total test portion.

NOTE: For typical calculations, see Appendix A.

- (f) For mixed aggregates, recalculate the ratio of coarse material to the total washed portion (R_c) and the ratio of fine material to the total washed portion (R_f).
- (g) By riffing or quartering each fraction obtain test fractions of approximately the masses shown in Tables 1 and 2, as appropriate. Determine the mass of each test fraction (A_n , where n is the number of the test fraction).
- (h) Place each test fraction in the appropriate test container [see Clause 7(c)].

NOTE: If the test sample used in Item (a) is also used for the sodium sulphate test, some laboratories may find it more convenient to keep the grading fractions separate. This is permissible provided each fraction is washed over the 4.75 mm or 300 μm sieve [as in Item (d)]. If this procedure is used, the separation step in Item (e) is avoided.

TABLE 1
MINIMUM TEST FRACTION MASS
FOR COARSE AGGREGATE

Fraction		Minimum mass of test fraction
Passing size mm	Retained size mm	
75.0	53.0	3000
53.0	37.5	2000
37.5	26.5	1500
26.5	19.0	1000
19.0	13.2	750
13.2	9.5	500
9.5	4.75	300

TABLE 2
MINIMUM TEST FRACTION MASS FOR FINE AGGREGATE

Fraction		Minimum mass of test fraction
Passing size	Retained size	
mm	mm	
4.75	2.36	100
2.36	1.18	100
1.18	0.600	100
0.600	0.300	100

11 PROCEDURE

The test procedure shall be as follows:

- (a) Immerse the containers with the test fractions in the prepared solution of sodium sulfate so that the test fractions are covered by the solution to a depth of at least 15 mm.
- (b) Maintain the temperature of the solution at $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 16 h to 18 h. During the immersion period do not agitate the test portions. Cover the bath to prevent evaporation of the solution or contamination of the test fractions.
- (c) At the end of the immersion period, remove the containers and test fractions from the solution. Allow each container to drain for a period of 15 ± 5 min.
- (d) Dry the containers and test fractions to constant mass in the evaporation oven operating at 105°C to 110°C .

NOTES:

- 1 To achieve the full potential of the test, the sodium sulfate is required to fully dehydrate. Care needs to be taken to ensure the oven does not build up humidity and thus increase the time required to achieve constant mass.
- 2 A laboratory may complete the immersion period overnight and dry the test portions through the day. This Step may be deemed to conform to this Standard provided the laboratory can demonstrate that under conditions of maximum loading of the oven and in the final cycle of this Standard, the test fractions achieve constant mass.
- 3 If a laboratory is required to carry out a considerable number of tests for sodium sulfate soundness, it may be of advantage, and will save time, if the operator predetermines a minimum drying time sufficient to bring samples of the requisite size to constant mass under the existing conditions of oven size, ambient temperature, humidity, and any other relevant factors.

Once such minimum drying time is known, a drying time not less than this minimum may be used for drying the sample throughout the five (5) cycles of the test. Under these conditions it would not be necessary to determine the mass of the dried sample to determine when constant mass is achieved until the end of the final cycle.

- (e) Allow the test fractions to cool and then re-immerses the containers and test fractions in the solution. Continue the process of immersion and drying for a total of five (5) cycles.
- (f) At the completion of the fifth cycle, allow the test fractions to cool. Place the containers and test fractions in warm water and dissolve the sodium sulfate from the test fractions. Wash the test fractions free of sodium sulfate in such a manner as to avoid any loss of test material.
- (g) Ensure that the test fractions are free of sulfate by mixing a small amount of the wash water with a dilute solution of barium chloride (BaCl_2). If no white precipitate appears then the fractions are free of sulfate.
- (h) Dry the test fractions to constant mass in an oven operating at 105°C to 110°C .