



Designation: D5240/D5240M – 20

Standard Test Method for Evaluation of the Durability of Rock for Erosion Control Using Sodium Sulfate or Magnesium Sulfate¹

This standard is issued under the fixed designation D5240/D5240M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This test method covers test procedures for evaluating the soundness of rock for erosion control by the effects of a sodium or magnesium sulfate solution on slabs of rock. It is an accelerated weathering test. The rock slabs, prepared in accordance with procedures in Practice D5121, are intended to be representative of erosion control sized materials and their inherent weaknesses. The test is appropriate for breakwater stone, armor stone, riprap and gabion sized rock materials.

1.1.1 The limitations of this test are twofold. First the test is a simulation of freezing and thawing conditions using accelerated life cycling techniques. The test evaluates the internal expansive force derived from the rehydration of the salt upon re-immersion, an event that may not occur in some natural environments, to simulate the expansion of water rather than the actual freezing of water. Secondly, the size of the cut rock slab specimens may eliminate some of the internal defects present in the rock structure. The test specimens may not be representative of the quality of the larger rock samples used in construction. Careful examination of the rock source and proper sampling are essential in minimizing this limitation.

1.2 The use of reclaimed concrete and other materials for erosion control is beyond the scope of this test method.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.3.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass

is slugs. The slug unit is not given unless dynamic ($F=ma$) calculations are involved.

1.3.2 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This practice implicitly combines two separate systems of units; the absolute and the gravitational systems. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording density in lbm/ft³ shall not be regarded as nonconformance with this standard.

1.3.3 Calculations are done using only one set of units; either SI or gravitational inch-pound. Other units are permissible, provided appropriate conversion factors are used to maintain consistency of units throughout the calculations, and similar significant digits or resolution, or both are maintained.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.4.1 For purposes of comparing measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal or significant digits in the specified limits.

1.4.2 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analytical methods for engineering design.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

¹ This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.17 on Rock for Erosion Control.

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*A Summary of Changes section appears at the end of this standard

1.6 This international standard was developed in accordance with internationally recognized principles on standardization established in the *Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee*.

2. Referenced Documents

2.1 ASTM Standards:²

- [C88/C88M Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate](#)
- [C295/C295M Guide for Petrographic Examination of Aggregates for Concrete](#)
- [D653 Terminology Relating to Soil, Rock, and Contained Fluids](#)
- [D2216 Test Methods for Laboratory Determination of Water \(Moisture\) Content of Soil and Rock by Mass](#)
- [D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction](#)
- [D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing](#)
- [D4992 Practice for Evaluation of Rock to be Used for Erosion Control](#)
- [D5121 Practice for Preparation of Rock Slabs for Durability Testing](#)
- [D5313/D5313M Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions](#)
- [D6026 Practice for Using Significant Digits in Geotechnical Data](#)
- [E100 Specification for ASTM Hydrometers](#)
- [E145 Specification for Gravity-Convection and Forced-Ventilation Ovens](#)

3. Terminology

3.1 Definitions:

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology [D653](#).

3.1.2 *gabion-fill stone, n—in rock*, stone generally less than 22 kg [50 lb] and placed in baskets of wire or other suitable material that is tied together to form an integral structure designed to resist erosion along stream banks and around bridge piers as well as stabilize shorelines, stream banks or slopes as well as retaining walls, noise barriers, temporary flood walls, silt filtration from runoff, for small or temporary/permanent dams, or channel lining. [D5121, D5313/D5313M](#)

3.1.3 *rock saw, n—in rock*, a saw capable of cutting rock. [D5121, D5313/D5313M](#)

3.1.3.1 *Discussion*—The term “rock saw” shall include the cutting mechanisms that saw the rock, any components that control or power the sawing process or both, any components

to cool or wash away cuttings from the cutting area, and framework on which the cutting mechanisms and any other associated components are mounted or held. The cutting mechanism can be a blade or a wire, with or without abrasive materials such as diamonds to assist in the cutting process, especially for harder rocks.

3.1.4 *slab, n—in rock*, a section of rock having two smooth, approximately parallel faces, produced by two saw cuts spaced such that the thickness of the slab is generally less than the other dimensions of the rock. [D5121, D5313/D5313M](#)

3.1.4.1 *Discussion*—The slab will be the rock specimen which will subsequently undergo durability tests. The words “slab” and “specimen” are interchangeable throughout the test method.

4. Summary of Test Method

4.1 Erosion control rock samples are trimmed into saw-cut slab specimens. The trimmed slabs are oven-dried to a constant mass. The specimens are repeatedly immersed in saturated solutions of sodium sulfate or magnesium sulfate followed by oven drying. At the completion of the test, the percent loss by mass for each specimen set is determined. A visual examination of the slabs is performed at the end of testing. The type of deterioration and changes to previously noted planes of weakness are recorded.

5. Significance and Use

5.1 Rock for erosion control consists of individual pieces of natural stone. The ability of these individual pieces of stone to resist deterioration due to weathering action affects the stability of the integral placement of rock for erosion control and hence, the stability of construction projects, structures, shorelines, and stream banks.

5.2 The sodium sulfate or magnesium sulfate soundness test is one method by which to estimate qualitatively the durability of rock under weathering conditions. This test method was developed to be used in conjunction with additional test methods listed in Practice [D4992](#). This test method does not provide an absolute value, but rather an indication of the resistance to freezing and thawing; therefore, the results of this test method are not to be used as the sole basis for the determination of rock durability.

5.3 This test method has been used to evaluate many different types of rocks. There have been occasions when test results have provided data that have not agreed with the durability of rock under actual field conditions; samples yielding a low soundness loss have disintegrated in actual usage, and the reverse has been true.

NOTE 1—The quality of results produced by this standard is dependent on the competence of the personnel performing it and suitability of the equipment and facilities used. Agencies that meet the criteria of Practice [D3740](#) are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice [D3740](#) does not in itself assure reliable results. Reliable results depend on many factors and Practice [D3740](#) provides a means of evaluating some of them.

6. Apparatus

6.1 *Rock Saw*—A laboratory water-cooled diamond saw used to cut geological and concrete specimens, or a diamond

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

saw used for lapidary purposes, shall be acceptable. A minimum blade diameter of 36 cm [14 in.] will be needed to obtain the required slab sizes (a larger blade is preferable). The blade shall be a circular diamond blade.

6.1.1 The rock saw apparatus shall have a fixed or removable vise to hold the samples during the cutting process. An automatic feed (either gravity, hydraulic, or screw-feed operated) that controls the cutting action is preferred; however, a manual feed is also acceptable. The saw shall have a platform to prevent the cut slab from falling and shattering.

NOTE 2—Coolants other than water may interfere with subsequent testing or evaluation, or both.

6.2 *Containers*—Of sufficient size to hold the specimens and baskets fully immersed in a sulfate solution. It is advised that these containers be sealable, non-reactive, resistant to breakage, and resistant to deformation and degradation when exposed to the chemicals and temperatures encountered in this test method.

6.3 *Baskets*—Baskets for immersing the slab specimens in the solution, in accordance with the procedure described in this test method, shall be perforated in such a manner as to permit free access of the solution to the specimen and drainage of the solution from the specimen without loss of material.

NOTE 3—Baskets made of suitable wire mesh or sieves with suitable openings are satisfactory containers for the samples.

6.4 *Temperature Regulation*—Suitable means for regulating the temperature of the samples at 21 ± 1 °C [70 ± 2 °F] during immersion in the sodium sulfate or magnesium sulfate solution shall be provided.

6.5 *Balances*—The balance shall meet the requirements of Specification **D4753**. A Class GP 10 balance of 5 g readability and accuracy is acceptable.

6.6 *Drying Oven*—Thermostatically controlled oven meeting the requirements of Specification **E145** and capable of maintaining a uniform temperature of 110 ± 5 °C [230 ± 9 °F] throughout the drying chamber. These requirements typically require the use of a forced-draft type oven. Preferably the oven should be vented outside the building.

6.7 *Specific Gravity Measurement*—Hydrometers conforming to the requirements of Specification **E100**, or a suitable combination of graduated glassware and balance, capable of measuring the solution specific gravity within ± 0.001 is acceptable.

6.8 *Camera*—A digital or film camera capable of producing good quality, color photographs for documenting “before” and “after” testing conditions of the specimen.

6.9 *Photographic Scale*—A scale of appropriate dimension and division when compared to the field of view and the detail being studied. When selecting a scale, always choose the scale that will provide at least as precise a measurement as the system that will be measuring the photographic information. If the system has a precision to one millimeter, make sure the scale used is accurate and precise to at least one millimeter across the entire scale.

6.10 *Containers*—Low form beakers, 1 liter.

7. Reagents and Materials

7.1 Prepare the solution for immersion of test samples from either sodium or magnesium sulfate in accordance with **7.1.1** or **7.1.2** (**Note 4**). The volume of the solution shall be at least five times the solid volume of all samples immersed at any one time.

NOTE 4—Some rock 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, repeat the test using a filtered solution that has been used previously to test the same type of carbonate rock, provided that the solution meets the requirements of **7.1.1** and **7.1.2** for specific gravity.

7.1.1 *Sodium Sulfate Solution*—Prepare a saturated solution of sodium sulfate by dissolving a reagent grade of the salt in water at a temperature of 25 to 30 °C [77 to 86 °F]. Add enough salt (**Note 5**), of either the anhydrous (Na_2SO_4) or the crystalline ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) form, to ensure not only saturation but also the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to 21 ± 1 °C [70 ± 2 °F]. Again stir, and allow the solution to remain at the designated temperature for at least 48 h before use. Prior to each use, break up the salt cake, if any, in the container, stir the solution thoroughly, and determine and record the specific gravity of the solution.

7.1.1.1 When used, the solution shall have a specific gravity of 1.151 to 1.174. Discard any discolored solution or filter it and check for specific gravity.

NOTE 5—For the solution, 215 g of anhydrous salt or 700 g of the decahydrate per litre of water are sufficient for saturation at 22 °C [71.6 °F]. However, since these salts are not completely stable and since it is desirable that an excess of crystals be present, the use of not less than 350 g of the anhydrous salt or 750 g of the decahydrate salt per litre of water is recommended.

7.1.2 *Magnesium Sulfate Solution*—Prepare a saturated solution of magnesium sulfate by dissolving a reagent grade of the salt in water at a temperature of 25 to 30 °C [77 to 86 °F]. Add enough salt (**Note 6**), of either the anhydrous (MgSO_4) or the crystalline ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) (Epsom salt) form, to ensure saturation and the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, always keep the solution covered when access is not needed. Allow the solution to cool to 21 ± 1 °C [70 ± 2 °F]. Again stir, and allow the solution to remain at the designated temperature for at least 48 h before use. Prior to each use, break up the salt cake, if any, in the container, stir the solution thoroughly, and determine and record the specific gravity of the solution. When used, the solution shall have a specific gravity of 1.295 to 1.308. Discard any discolored solution or filter it and check for specific gravity.

NOTE 6—For the solution, 350 g [0.8 lb] of anhydrous salt or 1230 g [2.7 lb] of the heptahydrate per litre [0.264 gal] of water are sufficient for saturation at 23 °C [73.4 °F]. However, since these salts are not



completely stable, with the hydrous salt being the more stable of the two, and since it is desirable that an excess of crystals be present, it is recommended that the heptahydrate salt be used and in an amount of not less than 1400 g/litre [11.7 lb/gal] of water.

7.1.3 *Barium Chloride Solution*—Prepare 100 mL [3.38 oz] of 5 % barium chloride solution by dissolving 5 g [0.176 oz] of BaCl₂ in 100 mL [3.38 oz] of distilled water.

NOTE 7—The 2004 iteration of this procedure, Test Method D5240-04, referred to Test Method C88/C88M. The references were to provide guidance in 1) the preparation of special solutions required and 2) the storage, drying, and cyclic requirements of the test specimens. The sections that had previously only cited Test Method C88/C88M have been expanded verbatim from Test Method C88/C88M, including all time temperature and special solution-specific gravity requirements, to permit Test Method D5240/D5240M to be a stand-alone method.

8. Sampling, Test Specimens, and Test Units

8.1 Rock source sampling shall be guided by the principles in Practice D4992.

8.2 Rock sources may be from mine, quarry, outcrop, or field boulders. Visual observation of color, texture, mineralogy, or some other feature, will be the key to proper representative sampling.

8.2.1 A rock source that is macroscopically uniform shall be represented by a minimum of five pieces of the material obtained from separate locations within the source area. This group is considered as a specimen set.

8.2.2 A rock source that is macroscopically non-uniform shall be represented by a minimum of eight pieces of the material obtained from separate locations within the source area. This group is considered as a specimen set.

8.2.3 Sample the rock types in their approximate proportion to the types that occur at the source.

8.3 Planes of weakness will be included in each sample such that a determination may be made as to the durability of the various planes of weakness and their effect on the overall durability of a rock mass that would contain these planes of weakness.

8.4 Each rock sample shall be of sufficient size to provide the finished size specimens described in Section 9.

8.5 In all cases, the rock pieces selected for the sample shall be chosen to be representative of the majority of the rock at the source. Rock pieces, as determined by their macroscopic properties, which comprise less than 5 percent of the source material, may be ignored unless their presence in a sample will significantly affect the test results and subsequent proposed use of the rock.

8.6 Each piece will be of a size such that testing may proceed without further mechanical crushing; however, the chosen pieces shall be as large as the laboratory can handle but in no case shall the sample be less than 125 mm [5 in.] on a side.

9. Preparation of Test Specimen

9.1 Prepare a separate slab for each orientation of the various planes of weakness unless all such planes can be intersected with one orientation.

9.2 Saw each sample, as obtained per 8.2.1 and 8.2.2, in accordance with Practice D5121. Cut each specimen to 65 ± 5 mm [2.5 ± 0.25 in.] thick and cut normal to bedding or any potential planes of weakness which may be observed in the samples. In no case will the size of the slab be less than 125 mm [5 in.] on a side, excluding the thickness.

NOTE 8—Test specimens may also be prepared by cutting a 65 ± 5 mm [2.5 ± 0.25 in.] thick slab from a 150-mm [6-in.] diameter diamond drill core such that any apparent zones of weakness are included.

NOTE 9—The best estimates of rock durability are those estimates that are based on the results of tests performed on the largest possible slabs of rock. The maximum slab size shall be limited only by the capacity of the laboratory and its equipment.

10. Calibration and Standardization

10.1 *Drying Oven:*

10.1.1 The rate of evaporation, at the range of temperature in 6.6, shall be at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-L low-form beakers, each initially containing 500 g [1 lb] of water at a temperature of 21 ± 2 °C [70 ± 3 °F], placed at each corner and the center of each shelf of the oven.

10.2 The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

11. Procedure

11.1 Label each test specimen with a suitable waterproof marker.

11.2 Before testing, photograph each test specimen digitally or using color film and in such a way that the slab fills most of the photograph. Wet or partially wetted test specimens usually show more detail than dry specimens. Provide close-ups of any unusual features. Include a scale in all photographs.

11.3 Describe each slab as indicated in Practice D5121. Note the presence of bedding planes, fractures, and other planes of weakness and their condition.

11.4 *Drying Specimens Before Immersion*—Dry each trimmed slab in an oven to a constant mass (± 0.1 % of total mass) at 110 ± 5 °C [230 ± 9 °F] and record the mass, without cooling, after each drying cycle. However, when determining constant mass for rock that contains gypsum (calcium sulfate dihydrate), the rock slab shall be dried at the 60 °C [140 °F] temperature recommended in Test Method D2216. In most cases, constant mass is reached after drying slabs overnight (12 to 16 h). In cases where there is doubt concerning the adequacy of drying, continue drying until the change in mass after two subsequent time intervals (greater than 1 h) the change in mass is less than 0.1 %. After constant mass has been achieved, allow the specimens to cool to ambient room temperature.

11.5 *Immersion of Specimens in Solution*—Immerse the slabs in the prepared solution of sodium sulfate or magnesium sulfate for 16 to 18 h in such a manner that the solution covers them to a depth of at least 12.5 mm [0.5 in.]. Cover the containers to reduce evaporation and to prevent contamination. Maintain the specimens immersed in the solution at a temperature of 21 ± 1 °C [70 ± 2 °F] for the immersion period.