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Standard Practice for Creating a Correlation to Compare Particle Size Distribution Results of Proppants by Dynamic Imaging Analyzers and Sieves[1]

This standard is issued under the fixed designation D8200; 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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes procedural steps to create a correlation that can be used to compare results of proppant size distributions between dynamic imaging analyzers (analyzers) and prescribed sieve sets.

1.2 The proppant size and distribution specifications that are included in this practice are listed in API Standard 19C (API 19C) and shown in Table 1, however as industry evolves additional specifications may come into use and this practice can be used with those as well.

1.3 This practice may not be applicable to all proppant types and designations. The acceptability of the correlations determined are judged by the operator.

1.4 The values stated in SI units are to be regarded as the standard, except sieve designations are typically identified using the 'alternative' system in accordance with Practice E11, such as 3 in. and No. 200 instead of the 'standard' system of 75 mm and 75 µm, respectively.

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values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.5.1 The procedures used to specify how data are collected/recorded and calculated in Practice D6026 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 these test methods to consider significant digits used in analysis methods for engineering data.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title means only that the document has been approved through the ASTM consensus process.*

1.7 *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.*

1.8 *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]

D75 Practice for Sampling Aggregates
D653 Terminology Relating to Soil, Rock, and Contained Fluids
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
D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.26 on Hydraulic Fracturing.

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[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.

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *API Standard:*[3]

Standard 19C Measurement of and Specifications for Proppants Used in Hydraulic Fracturing and Gravel Packing Operations.

3. Terminology

3.1 For definitions of common technical terms used in this standard refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *correlation fit file, n—in proppant particle size testing*, a software based, data analysis algorithm used to correlate analyzer results to sieve results.

3.2.2 *dynamic imaging analyzer, n—in proppant particle size testing*, any instrument employing a camera or other visual sensor, with appropriate illumination, to digitally capture and analyze images, via an image processor, of moving particles conducted through a measurement zone.

3.2.3 *proppant, n—in hydraulic fracturing*, a solid granular material designed to keep an induced hydraulic fracture open during or following a fracturing treatment.

3.2.3.1 *Discussion*—Typically such granular material is composed of processed sand, resin coated sand, ceramic, resin coated ceramic and other manufactured materials having a limited range of particle/sieve sizes which are less than 4.75 mm and with negligible fines.

3.2.4 *reticle, n*—a measurement scale, traceable to NIST, with 100 µm and 10 µm subdivisions which spans approximately 80 % of the field of view which is used in order to calibrate the analyzer.

4. Summary of Practice

4.1 The practice contains procedural steps that can be followed in order to correlate results of proppant size distributions determined from prescribed sieve sets (see Table 1) and results from analyzers.

4.2 A correlation is determined based on testing of the actual proppant it is being created for. Representative proppant samples are obtained and test specimens are created and tested by the sieve sets and then by the analyzer. The data is compared and a correlation is determined and then tested on additional proppant specimens.

4.3 Each correlation fit file is created for each proppant designation and contains the correlation factors the analyzer uses to match its results to the sieve set. Each is particular to a single set of test sieves. If physical changes are made to either the sieve set or analyzer the procedure must be repeated to re-establish the correlation.

5. Significance and Use

5.1 The ability to correlate results of analyzers to sieve sets enables the use of non-sieve methods to be employed that give comparable results to each other.

5.2 The use of analyzers for proppant measurement has the benefit of providing particle shape characteristics which are important in the performance of these materials. Shape analysis is currently done by operator's determination based on a visual observation of a small number of particles per API 19C. Available information from imaging analysis of many particles can be used to assess the proppant shape characteristics as opposed to just a small number.

6. Apparatus

6.1 *Dynamic Imaging Analyzer.*

6.2 *Calibration Sieves,* specified in Table 1, 8 in. diameter in size meeting calibration grade per Specification E11.

6.3 *Working Sieves,* specified in Table 1, 8 in. diameter in size meeting compliance grade per Specification E11.

6.4 *Box Sampling Device,* meeting requirements of Test Method D6913.

6.5 *Sample Splitter,* meeting requirements of Test Method D6913.

6.6 *No. 200 wash screen.*

6.7 *Balance,* minimum 500 g capacity and meeting Guide D4753 with a minimum resolution of 0.01 g.

6.8 *Oven,* capable of containing a 500 g proppant sample and maintaining a uniform temperature of 110 °C ± 5 °C.

7. Reagents and Materials

7.1 *Proppant,* sampled from the actual materials that will be measured going forward.

8. Sample and Specimen Preparation

8.1 A total of three representative proppant samples, each approximately 200 g in mass, will be obtained in accordance with Practice D75.

8.2 Follow the moist procedure, single sieve set sieving instructions of Test Method D6913 for the following:

8.2.1 Use a sample splitter (6.5) to divide each sample into two specimens of approximately 100 g that will be used to create the correlation.

8.2.2 Dry each specimen and determine its mass.

8.2.3 Wash each specimen using a No. 200 wash screen, then dry the sample and record its mass. The difference in mass from 8.2.2 represents the amount passing No. 200.

[3] Available from American Petroleum Institute (API), 200 Massachusetts Ave. NW, Suite 1100, Washington, DC 20001, http://www.api.org.

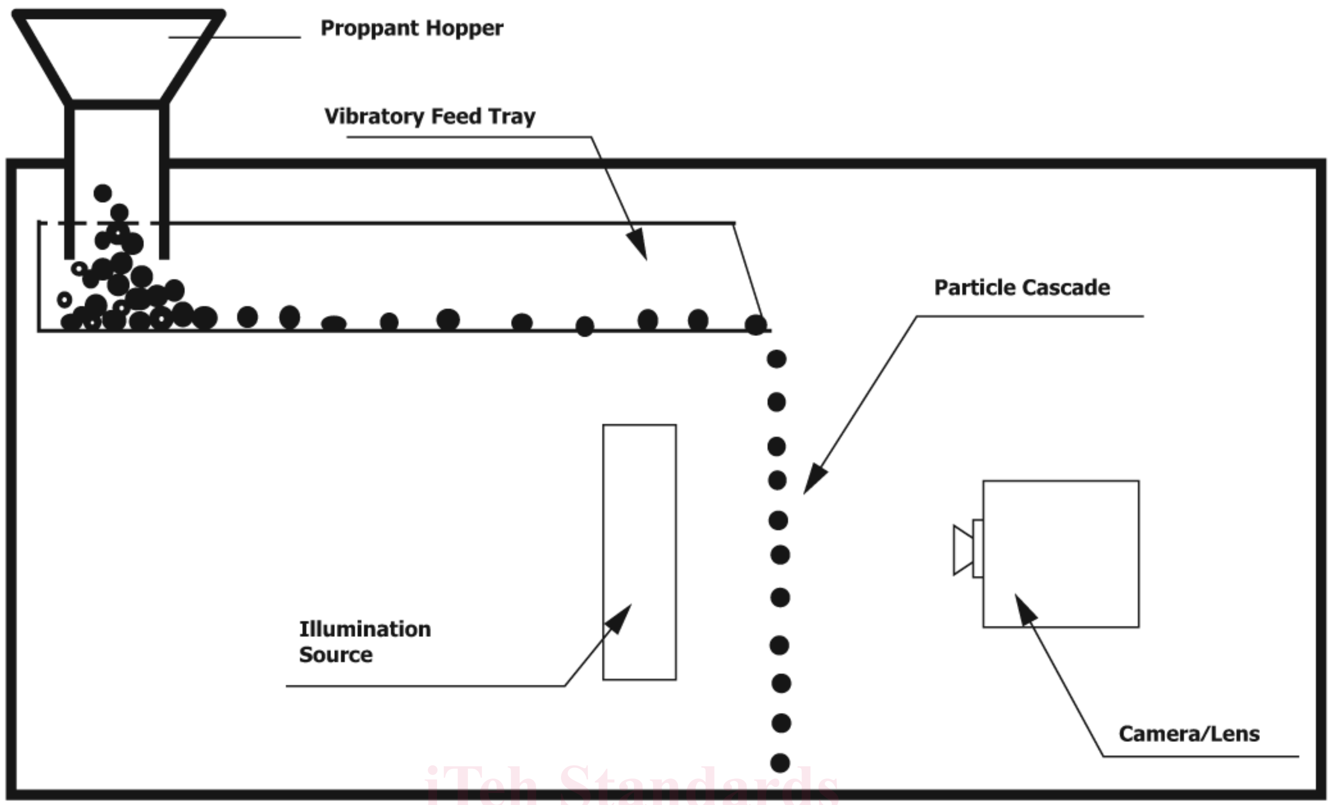

FIG. 1 Basic Component Diagram of Direct Imaging Analyzer

TABLE 1 Typical Proppant Grades

	Sieve-opening Sizes µm										
	3350/ 1700	2360/ 1180	1700/ 1000	1700/ 850	1180/ 850	1180/ 600	850/ 425	600/ 300	425/ 250	425/ 212	212/ 106
	Typical Proppant/Gravel-pack Size Designations										
	6/12	8/16	12/18	12/20	16/20	16/30	20/40	30/50	40/60	40/70	70/140
	Stack of ASTM Sieves										
Upper designating sieve in bold type	4	6	8	8	12	12	16	20	30	30	50
	6	**8**	**12**	**12**	**16**	**16**	**20**	**30**	**40**	**40**	**70**
	8	10	14	14	18	18	25	35	45	45	80
Lower designating sieve in bold type	10	12	16	16	**20**	20	30	40	50	50	100
	12	14	**18**	18	25	25	35	45	**60**	60	120
	14	**16**	20	**20**	30	**30**	**40**	**50**	70	**70**	**140**
	16	20	30	30	40	40	50	70	100	100	200
	pan	pan	pan	pan	pan	pan	pan	pan	pan	pan	pan

9. Procedure

9.1 Follow the manufacturer's operating manual for set up, operation and calibration of the analyzer.

9.2 *Sieve Distribution:*

9.2.1 From Table 1 assemble a working sieve set for testing, which corresponds to the proppant grade to be assessed.

NOTE 1—The information in Table 1 is for reference only. These sieve set descriptions may be altered from time to time based on industry needs, and API 19C is the governing standard in this regard.

9.2.2 Follow the instruction of Test Method D6913 to sieve the six specimens prepared in accordance with Section 8 and determine the percent held on each screen (remembering to include the percent passing the No. 200 wash screen). Once all specimens are sieved, take the results for each specimen and average them together to produce a single result for each gradation. Confirm this result meets the acceptance criteria of API 19C, which are:

9.2.2.1 Percent mass passing the coarse designated sieve and retained above the fine designated sieve is 90 % or greater. For example, a 30/50 proppant would have 90 % of the total mass passing the No. 30 sieve and retained above the No. 50 sieve.

9.2.2.2 Percent mass on the top screen in the stack is 0.1 % or less.

9.3 *Analyzer Distribution:*

9.3.1 Set the analyzer gradation boundaries to match the sieve set selected in 9.2.1.

9.3.2 Select one of the six test specimens and test in the analyzer and record the percent held for each gradation.

9.3.3 Compare the percent held for each gradation of the analyzer (9.3.2) to the average percent held on each sieve of the sieve set (9.2.2). Adjust the gradation boundaries of the analyzer so the percent passing at each gradation closely matches the sieve results. Save these settings as the correlation fit file. For an explanation on how this can be done see Annex A1.

NOTE 2—Various analyzers have software methods to perform the correlation in 9.3.4. A single method is not mandatory.

9.3.4 Test the remaining five samples, as in 9.3.2, in the analyzer and produce size distribution results using the boundary settings determined in 9.3.3.

NOTE 3—The acceptability of the accuracy and repeatability of the correlation is per the judgment of the operator. Appendix X1 contains results of one manufacturer's analyzer testing 30/50, 40/70 and 100 mesh frac sands. The 100 mesh in this case is a 60/140 grade.

9.3.5 If adjustments to the gradation boundaries are desired to improve the correlation, repeat step 9.3.4.

9.3.6 Once the operator judges the fit file settings satisfactory, it is saved and no further changes can be made unless the correlation is re-established by following the procedure of Section 9. Should there be changes in the sieve set used for comparison, the correlation must be reestablished.

9.3.7 To test repeatability select one of the samples tested in 9.3.4 and run it 20 times through the analyzer to produce size distribution results. Repeatability can be calculated for each gradation and for the in-spec percentage which is the percent of the total passing the coarse designated sieve and retained above the fine designated sieve of the proppant designation. See 9.2.2.1. See Appendix X1 for typical data.

10. Reporting

10.1 For documentation purposes, the recommended minimum reporting for the results of the correlation are:

10.1.1 Average percent mass of proppant passing through the coarse designated sieve and retained above the fine designated sieve of the five proppant specimens tested for correlation.

10.1.2 The average result of the five test specimens (10.1.1) as measured by the analyzer.

10.1.3 Adjusted gradation boundaries of the instrument.

10.1.4 Correlation date.

10.1.5 Analyzer serial number.

10.1.6 Reference to this standard.

10.1.7 For subsequent proppant measurements by the analyzer it is recommended that the results report include a reference to this standard.

11. Keywords

11.1 correlation fit file; dynamic imaging; particle size; proppant

ANNEX

A1. ANALYZER CORRELATION ADJUSTMENT

(Mandatory Information)

A1.1 This annex gives an illustrative description for creation of a correlation between two sets of data.

A1.2 Correlation

A1.2.1 Plot data from the sieve set result versus the analyzer result in a cumulative percent passing form (see Fig. A1.1 and Fig. A1.2).

A1.2.2 The vertical scale represents the % passing percentage. Slide the blue dots, which represent the analyzer gradation boundaries, down the curve until they match the percent passing values of the sieve curve. The corresponding sizes values, along the horizontal axis, then become the new analyzer gradation boundaries. In the example shown, the 355 µm boundary would become 345 µm, the 425 µm boundary would become 405 µm, the 500 µm boundary would become 485 µm, the 600 µm boundary would become 575 µm and the others would remain unchanged. These values are entered into the fit file for the analyzer.