



Standard Test Method for Determination of Attrition and Abrasion of Powdered Catalysts by Air Jets¹

This standard is issued under the fixed designation D5757; 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 test method covers the determination of the relative attrition characteristics of powdered catalysts by means of air jet attrition. It is applicable to spherically or irregularly shaped particles which range in size between 10 and 180 μm , have skeletal densities between 2.4 and 3.0 g/cm^3 (2400 and 3000 kg/m^3) (see [IEEE/ASTM SI-10](#)) and are insoluble in water. Particles less than 20 μm are considered fines.

1.2 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

[E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods](#)

[E456 Terminology Relating to Quality and Statistics](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

[IEEE/ASTM SI-10 Standard for Use of the International System of Units \(SI\): The Modern Metric System²](#)

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *Air Jet Index (AJI)*—a unitless value numerically equal to the percent attrition loss at 5 h.

4. Summary of Test Method

4.1 A sample of dried powder is humidified and attrited by means of three high velocity jets of humidified air. The fines

are continuously removed from the attrition zone by elutriation into a fines collection assembly.

4.2 The AJI is calculated from the elutriated fines to give a relative estimate of the attrition resistance of the powdered catalyst as may be observed in commercial use.

5. Significance and Use

5.1 This test method is intended to provide information concerning the ability of a powdered catalyst to resist particle size reduction during use in a fluidized environment.

5.2 This test method is suitable for specification acceptance, manufacturing control, and research and development purposes.

6. Apparatus

6.1 The air jet attrition system consists of the following:

6.1.1 *Attrition Tube*, a stainless steel tube 710-mm long with a 35-mm inside diameter.

NOTE 1—NPS 1/4-in. pipe, Schedule 40 has the appropriate inside diameter.

6.1.2 *Three 2-mm Long Drilled Sapphire Square Edged Nozzles*, precision drilled 0.381 ± 0.005 mm in diameter. They are mounted equidistant from each other, 10 mm from center and flush with the top surface in a circular orifice plate 6.4-mm thick. The plate is designed to be attached to the bottom of the vertical attrition tube within an air delivery manifold.

6.1.3 *Settling Chamber*, a 300-mm long cylinder with a 110-mm inside diameter and with conical ends reducing to 30-mm inside diameter. The upper cone is approximately 100-mm long and the lower cone is approximately 230-mm long. The chamber is mounted to the top of the attrition tube.

6.1.4 *Fines Collection Assembly*, made up of a 250-mL filtering flask, an extraction thimble connected to the side arms of the flask, and a 200 by 13-mm diameter metal tubing bent to an angle of 125° connecting the top of the flask to the top of the settling chamber.

NOTE 2—The flask may be eliminated and the thimble connected directly to the tubing if the attrition is expected to be low enough to avoid clogging the thimble and creating a backpressure in the settling chamber.

¹ This test method is under the jurisdiction of ASTM Committee D32 on Catalysts and is the direct responsibility of Subcommittee D32.02 on Physical-Mechanical Properties.

Current edition approved Oct. 1, 2006. Published November 2006. Originally approved in 1995. Last previous edition approved in 2000 as D5757-00. DOI: 10.1520/D5757-00R06.

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.

6.1.5 *Rubber Couplers and Seals*, appropriately sized to ensure tight and leak free connections of the system.

6.2 *Air Supply Source*, controlled and capable of maintaining an air flow rate of 10.00 L/min stable to 0.05 L/min at a pressure up to 200 kPa. The air must be at a relative humidity of 30 to 40 % to minimize electrostatic effects.

NOTE 3—The air may be bubbled through a 0.25-m column of deionized water at ambient temperature to obtain the required humidity.

6.3 *Diaphragm-Type Test Meter (dry test meter) or Liquid-Sealed Rotating Drum Meter (wet test meter)*, minimum capacity of 30 L/min and maximum scale subdivision of 0.1 L.

6.4 *Balance*, 400-g capacity open pan with 0.01-g sensitivity.

6.5 *Desiccator*, with a desiccant grade molecular sieve such as 4A.

6.6 *Muffle Furnace*.

6.7 *Relative Humidity Gage*.

7. Sampling

7.1 Obtain a representative sample of approximately 65 g of material from larger composites by riffing or splitting with the aim of obtaining a sample that represents the size distribution of the larger composite.

7.2 Gently screen the sample through a No. 80 (180 μm) ASTM sieve to remove any particles larger than 180 μm .

7.3 The step in 7.3.1 is followed for all samples except fresh FCC catalysts for proper equilibration at 35 % humidity to avoid absorption of water during the test.

7.3.1 Transfer the presieved sample to a shallow wide dish and place in a humidifier over a saturated calcium chloride solution for 16 h.

7.4 The steps in 7.4.1-7.4.4 are followed for fresh FCC catalysts to ensure a proper moisture level that will not change during the test.

7.4.1 Transfer the presieved sample to a shallow dish and dry it for 1 h in a muffle furnace preheated to 565°C.

7.4.2 Cool the sample to room temperature in a desiccator.

7.4.3 Mix 45 g of the dried and cooled material thoroughly with 5 g of demineralized water ensuring that the water is well dispersed and that there are no lumps of material present.

7.4.4 Allow the sample to stand over a saturated calcium chloride solution in a humidifier for 1 h.

8. Preparation of Apparatus

8.1 Thoroughly clean any residual material from the apparatus by tapping it loose and blowing or vacuuming the dust. Reassemble the system except for the fines collection assembly.

8.2 Turn on the air supply and adjust the relative humidity of the air exiting the settling chamber to a range of 30 to 40 %.

8.3 Connect the inlet of the wet test gas meter to the top of the settling chamber and adjust the humidified air flow to 10.00 \pm 0.05 L/min at standard temperature and pressure (STP) (273.15 K and 101.325 kPa). The back pressure should be in the range of 130 to 180 kPa; if it is not, check that the air jet nozzles are clean and within specifications and that there are no leaks in the apparatus connections.

8.4 Prepare two fines collection assemblies and condition the thimbles by installing them on the apparatus in succession and passing the humidified air through the apparatus for 30 min each.

9. Procedure

9.1 Weigh the first conditioned fines collection assembly to the nearest 0.01 g and record its mass.

9.2 With the air flowing at the prescribed 10.00 L/min and the fines collection assembly off, charge 50 g of water equilibrated sample to the apparatus through the top of the settling chamber, quickly secure the first fines collection assembly to the apparatus and start the timekeeping.

9.3 Weigh the second conditioned fines collection assembly to the nearest 0.01 g and record its mass.

9.4 After exactly 1 h from the start, replace the first fines collection assembly with the second one. Weigh and record the mass of the first fines collection assembly.

9.5 After exactly 5 h from the start, remove the fines collection assembly, weigh it, and record its mass.

9.6 Turn off the apparatus and disassemble.

9.7 Recover the sample from the attrition tube and settling chamber and weigh to the nearest 0.01 g.

9.8 Clean the apparatus.

10. Calculations

10.1 Calculate the percent fines lost in the first hour as follows:

$$\text{fines loss, \%} = (m_1 - m_0)/m_s \times 100 \quad (1)$$

where:

m_0 = mass of the first empty fines collection assembly at the start of the test, g,

m_1 = mass of the first fines collection assembly at 1 h, g, and

m_s = mass of the sample charged to apparatus (nominally 50 g).

10.2 Calculate the percent fines lost from attrition at the fifth hour as follows:

$$\text{attrition loss, \%} = (m_1 - m_0 + m_5 - m'_0)/m_s \times 100 \quad (2)$$

where:

m'_0 = mass of the second empty fines collection assembly, g, and

m_5 = mass of the second fines collection assembly at 5 h, g.

10.3 Calculate the percent sample recovery after the test as follows:

$$\text{recovery, \%} = (m_1 + m_5 + m_r - m_0 - m'_0)/m_s \times 100 \quad (3)$$

where:

m_r = mass of the sample recovered from the attrition tube and the settling chamber.

11. Report

11.1 Report the following information:

11.1.1 The AJI.

11.1.2 The first hour fines loss as percent.

11.1.3 The recovery as percent.

12. Precision and Bias

12.1 *Test Program*—An interlaboratory study was conducted in which the named property was measured in four separate test materials in four to seven separate laboratories. Practice E691, modified for nonuniform data sets, was followed for the data reduction. Analysis details are in the research report.

12.2 *Precision*—Pairs of test results obtained by a procedure similar to that described in the study are expected to differ in absolute value by less than $2.772 S$, where $2.772 S$ is the 95 % probability interval limit on the difference between two test results, and S is the appropriate estimate of standard deviation. Definitions and usage are given in Practices E456 and E177, respectively. See Table 1.

TABLE 1 Repeatability and Reproducibility

Test Result-AJl (consensus mean)	95 % Repeatability Interval (within laboratory)	95 % Reproducibility Interval (between laboratories)
2.530	0.226 (8.95 % of mean)	0.907 (35.9 % of mean)
4.209	0.279 (6.64 % of mean)	1.939 (46.1 % of mean)
20.353	1.121 (5.51 % of mean)	11.370 (55.9 % of mean)
39.945	1.414 (3.54 % of mean)	12.029 (30.1 % of mean)

12.3 *Bias*—The procedure in this test method for measuring attrition has no known bias because the value of the attrition loss is defined only in terms of this test method.

13. Keywords

13.1 abrasion; air jet; attrition; fines; powdered catalysts

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