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Standard Test Methods for Municipal Ferrous Scrap[1]

This standard is issued under the fixed designation E701; 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 These test methods cover various tests for assessing the usefulness of a ferrous fraction recovered from municipal wastes.

1.2 These test methods comprise both chemical and physical tests, as follows:

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1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *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.*

1.5 *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]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C702/C702M Practice for Reducing Samples of Aggregate to Testing Size

D2234/D2234M Practice for Collection of a Gross Sample of Coal

E30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron (Withdrawn 1995)[3]

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

E350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

E351 Test Methods for Chemical Analysis of Cast Iron—All Types

E415 Test Method for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry

E702 Specification for Municipal Ferrous Scrap

3. Significance and Use

3.1 The establishment of these test methods for municipal ferrous scrap as a raw material for certain industries (see Specification E702) will aid commerce in such scrap by providing the chemical and physical tests for the characterization of the scrap needed as a basis for communication between the purchaser and supplier.

4. Hazards

4.1 Due to the origins of municipal ferrous scrap in waste destined for disposal, common sense dictates that some precautions should be observed when conducting tests on the samples. Recommended hygienic practices include using gloves when handling municipal ferrous scrap and washing hands before eating or smoking.

5. Sampling

5.1 *Gross Sample of Loose Ferrous Scrap:*

5.1.1 Take a minimum of one gross sample having a volume of 7 ft^3 (0.2 m^3) (approximately equal to a 55-gal drum). Guidance for determining the number of gross samples needed to characterize a given lot of material and methods for

[1] These test methods are under the jurisdiction of ASTM Committee D34 on Waste Management and are the direct responsibility of Subcommittee D34.03 on Treatment, Recovery and Reuse.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

accumulating a gross sample can be found in Practices E122 and D2234/D2234M, respectively. In all cases, the actual sampling procedures to be used and the number of gross samples required to obtain a representative sample of the lot shall be established in accordance with an agreement between the purchaser and supplier.

5.1.2 Air-dry the gross sample at ambient temperature for a period of 24 h by spreading the sample on a clean, dry surface to one-layer thickness. Protect the sample from contamination by falling dust and debris. Reduce the gross sample to four samples by the method of coning and quartering, as described in Method B of Practice C702/C702M.

5.2 *Gross Sample of Baled Ferrous Scrap*—Take a minimum of two bales. Guidance for determining the number of bales needed to characterize a given lot of material and methods for selecting the bales can be found in Practice E122. In all cases, the actual sampling procedures to be used and the number of gross samples required to obtain a representative sample of the lot shall be established in accordance with an agreement between the purchaser and supplier.

6. Bulk Density

6.1 *Loose Ferrous Scrap:*

6.1.1 *Apparatus:*

6.1.1.1 *Container,* constructed of suitable materials, for example, plywood, having the following approximate internal dimensions: base of 1 by 1 ft (300 by 300 mm) and a height of at least 2 ft (600 mm). Measure the internal dimensions of the box to the nearest 0.1 in. (3 mm). Suitable handles may be attached to the exterior of the container to aid in subsequent handling. Alternatively, containers of other geometries agreeable to the purchaser and supplier may be employed provided the area of the base is at least 1 ft^2 (0.09 m^2).

NOTE 1—The operator should be aware that this test method is not intended for those occasional pieces whose size is of the order of the dimensions of the box. As a guide, the maximum length of a single piece should not exceed three-fourths of the maximum dimension of the base.

6.1.1.2 *Balance or Scale,* accurate within 0.1 % of the test load within the range of use. The range of use shall be considered to extend from the weight of the container empty to the weight of the container plus its contents at 100 lb/ft^3 (1600 kg/m^3).

6.1.1.3 *Measuring Rod,* calibrated in 0.1-in. (3-mm) intervals, having a blunt end with an area of 4 $in.^2$ (26 cm^2).

6.1.2 *Procedure:*

6.1.2.1 Use each of the four samples from 5.1.2 to determine the bulk density.

6.1.2.2 Before each determination, weigh the empty container to the nearest 0.1 lb (0.05 kg).

6.1.2.3 Place oversize pieces likely to protrude above the surface of the material in the container at the bottom of the container prior to filling with the remainder of the sample.

6.1.2.4 Fill the container in three approximately equal layers. After each layer, place the container on a firm base, for example, a concrete floor, raising the opposite sides alternately about 2 in. (50 mm) and allowing the container to drop in such a manner as to hit with a sharp, resounding impact. Do this settling step ten times, five times on each side, in the manner described. Level the surface of the material manually to minimize surface irregularities.

6.1.2.5 Using the measuring rod described in 6.1.1.3, measure the distance from the top of the container to the surface of the material to the nearest 0.1 in. (3 mm) in each of the four corners of the container. Subtract the average of the four measurements from the inside height of the container to determine the height of the material.

6.1.2.6 Weigh the filled container to the nearest 0.1 lb (0.05 kg).

6.1.3 *Calculation*—Calculate the bulk density as follows:

$$\text{Bulk density, lb/ft}^3\ (\text{kg/m}^3) = \frac{a-b}{c \times d \times e} \times f \qquad (1)$$

where:

a = weight of container plus material, lb (or kg),
b = weight of container, lb (or kg),
c = inside length of container base, in. (or m),
d = inside depth of container base, in. (or m),
e = height of material in container, in. (or m), and
f = 1 for container dimensions measured in metres, or 1728 for container dimensions measured in inches.

6.1.4 *Report*—Report each bulk density determination and the average of the four determinations.

6.2 *Baled Ferrous Scrap:*

6.2.1 *Procedure:*

6.2.1.1 Determine the weight of each bale from 5.2 to the nearest 0.1 lb (0.05 kg) using a scale described in 6.1.1.2.

6.2.1.2 Measure individually the length, width, and height of the bale to the nearest 0.1 in. (3 mm).

6.2.2 *Calculations*—Calculate the bulk density as follows:

$$\text{Bulk density, lb/ft}^3\ (\text{kg/m}^3) = \frac{g}{h \times i \times j} \times k \qquad (2)$$

where:

g = weight of bale, lb (or kg),
h = length of bale, in. (or m),
i = width of bale, in. (or m),
j = height of bale, in. (or m), and
k = 1 for bale dimensions measured in metres, or 1728 for bale dimensions measured in inches.

6.2.3 *Report*—Report each bulk density determination and the average of all of the determinations.

7. Total Combustibles

7.1 *Procedure:*

7.1.1 Use two of the four bulk density volumes from 6.1.2.1 for the total combustibles determination. Reduce the size of each sample, if necessary, to approximately 20 lb (9.1 kg) by the method of coning and quartering as described in Method B of Practice C702/C702M. Determine the weight of each of the two samples to the nearest 0.1 lb (0.05 kg) before heating.

7.1.2 Heat each of the two samples in excess air at 750 °F (400 °C) for 60 min. An external source of air at low flow rates and pressures can be introduced at several locations within the sample to provide for combustion and excess air. The sample may be stirred every 15 min to expose fresh surface. Determine

the weight of each of the two samples after heating to the nearest 0.1 lb (0.05 kg).

NOTE 2—For example, the amount of air needed can be estimated as in the following example:

Assume a 20-lb (9-kg) sample containing 10 % combustibles that are 40 % carbon. For complete combustion, the amount of carbon to be removed is:

$$20 \times 0.1 \times 0.4 = 0.8 \text{ lb} \quad (3)$$

For the combustion reaction $C + O_2 = CO_2$, 0.8 lb of carbon requires $0.8 \times (32 \text{ lb/lb·mol})/(12 \text{ lb/lb·mol}) = 2.13$ lb of oxygen or $2.13 \times (359 \text{ ft}^3\text{/lb·mol})/(32 \text{ lb/lb·mol})$ of $O_2 = 23.9 \text{ ft}^3$ of oxygen at standard temperature and pressure (STP). Assuming the oxygen contribution from the sample is zero, and since air is 21 % oxygen by volume, $23.9/0.21 = 114 \text{ ft}^3$ of air at STP is required to react with the carbon. For air at 25 °C (77 °F), the volume of air required is $114 \times (273 + 25)/273 = 124 \text{ ft}^3$, and assuming a 50 % excess air requirement, the total air necessary is $124 + 0.5 = 186 \text{ ft}^3$. For a combustion time of 60 min, the flow rate of air needed is $186/60 = 3.1 \text{ ft}^3\text{/min}$.

7.2 *Calculation*—Calculate the total combustibles as follows:

$$\text{Total combustibles, weight \%} = [1 - (w_1/w_2)] \times 100 \quad (4)$$

where:

w_1 = sample weight after heating, and
w_2 = sample weight before heating.

7.3 *Report*—Report each determination of total combustibles and the average of the two determinations.

8. Chemical Analysis (for Industries Other Than the Detinning Industry)

8.1 Reduce the two bulk density volumes remaining after Section 7 to two 30-lb (13.6-kg) samples, if necessary, and melt each in an induction furnace under a blanket of argon gas.

8.2 Take a sample of each melt and prepare for chemical analysis in accordance with one of the following test methods: E30, E350, E351, E415, or to procedures mutually agreed upon by the purchaser and the supplier.

8.3 Report the chemical composition of each melt and the average composition of the two melts.

9. Magnetic Fraction (for the Detinning Industry)

9.1 *Procedure:*

9.1.1 Weigh each of the two bulk density volumes remaining after Section 7 to 0.1 lb (0.05 kg) and manually separate using a hand magnet into two fractions: magnetic and nonmagnetic.

9.1.2 Wash the magnetic fraction in a galvanized tub of approximately 20-gal (0.08-m^3) capacity for 2 min with 180 °F (82 °C) water. Locate a 2-in. quick-drain valve, or equivalent, at the base of the tub to drain the water and wash the residue. When the drain valve is opened, use water from a garden hose for approximately 1 min to wash off any remaining residue. Place a ¼-in. (6.3-mm) hardware cloth with sufficient screening area at the exit of the drain valve to collect any of the magnetic fraction that may be washed out through the drain valve during draining of the tub. Next, repeat the previously described wash cycle. Manually remove the magnetic fraction from the tub and drain, if necessary, any residue or retained water, or both, from the individual pieces. After draining the water, air-dry the magnetic fraction at ambient temperature for a period of 24 h by spreading the sample onto a clean, dry surface to one-layer thickness, or as required by Test Method C29/C29M, and weigh to the nearest 0.1 lb (0.05 kg). While drying, protect the sample from contamination by falling dust and debris.

9.2 *Calculation*—Calculate the magnetic fraction as follows:

$$\text{Magnetic fraction, weight \%} = \frac{w_3}{w_4} \times 100 \quad (5)$$

where:

w_3 = weight of magnetic fraction, and
w_4 = weight of as-received sample (from 9.1.1).

9.3 *Report*—Report each determination of the magnetic fraction and the average of the two determinations.

10. Chemical Analysis for Tin (for the Detinning Industry)

10.1 *Procedure:*

10.1.1 Separate manually each dried magnetic portion from Section 9 into "cans and other." Weigh the can and other fractions to the nearest 0.1 lb (0.05 kg). Prepare the can fraction for sampling by compacting it to sufficient density to maintain its integrity during subsequent drilling. The cylindrical compact should have a volume of approximately 10 $in.^3$ (160 cm^3).

10.1.2 Drill two ¼-in. (6-mm) holes through the cylinder from top to bottom. Locate the holes on the base of the cylinder, midway between the cylinder axis and the cylinder edge on a common diameter.

10.1.3 Combine the drillings from the two holes for the chemical analysis described in 10.1.5. Exercise caution to ensure the collection of all drillings.

NOTE 3—Experience has shown that approximately 20 g of drillings is a sufficient sample for the tin analysis.

10.1.4 Alternatively, the can fraction can be sampled by any other procedure mutually agreed upon between the purchaser and the supplier.

10.1.5 Prepare the sample for tin analysis in accordance with Sections IIIA and IIIB1 of the *Treatise on Analytical Chemistry*[4] or to procedures mutually agreeable to the purchaser and the supplier. The analysis result is the weight percent tin in the can fraction.

10.2 *Calculation*—Calculate the tin content as follows:

$$\text{Tin content of as-received sample, weight \%} = \frac{w_5}{w_6} \times w_7 \quad (6)$$

where:

w_5 = weight of can fraction,
w_6 = weight of as-received sample (from 9.1.1), and

[4] *Treatise on Analytical Chemistry*, edited by Kolthoff, Elving, and Sandell, Part II, Vol 3, Interscience Publishers, New York, NY, 1961.

w_7 = weight % of tin in can fraction.

10.3 *Report*—Report the tin content as percent tin by weight of the as-received sample.

11. Metallic Yield for All Industries Other Than the Copper Industry and the Detinning Industry

11.1 *Procedure*—Determine the metallic yield from each of the samples used for the chemical analysis in Section 8.

11.2 *Calculation*—Calculate the metallic yield as follows:

$$\text{Metallic yield, weight \%} = \frac{w_8}{w_9} \times 100 \quad (7)$$

where:

w_8 = weight of metal after melting (Note 4), and

w_9 = weight of total sample before melting.

NOTE 4—Weight includes portion removed for chemical analysis and excludes weight of slag formed.

11.3 *Report*—Report each determination of metallic yield and the average of the two determinations.

12. Precision and Bias

12.1 The precision and bias of these test methods have not yet been established.

13. Keywords

13.1 bulk density; chemical analysis; magnetic fraction; metallic yield; municipal ferrous scrap; sampling; test methods; total combustibles