Designation: E 868 – 82 (Reapproved 1999)

Standard Test Methods for Conducting Performance Tests on Mechanical Conveying Equipment Used in Resource Recovery Systems[1]

This standard is issued under the fixed designation E 868; 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 include descriptions for conducting and reporting throughput and electrical power tests on mechanical conveying equipment for municipal solid waste and recovered products from resource recovery systems. Other aspects of performance testing such as spillage, conveyor tracking, dusting, slippage, transfer points, etc., should be considered in the interpretation of the results. These test methods can be used on equipment handling raw refuse, processed refuse, magnetic scrap metals, nonferrous scrap metals, mixed glass, and residues or tailings. These test methods may also be used for materials in other industries.

1.2 These test methods cover mechanical conveying equipment including apron, belt, drag, flight, screw, slat, and vibrating conveyors and bucket elevators.

1.3 These test methods are applicable specifically to the resource recovery industry since municipal solid wastes are heterogeneous mixtures and the composition and bulk densities vary considerably depending on many factors. Because of the varying composition of municipal solid waste, a number of samples must be taken to determine accurately the performance of the mechanical conveying equipment.

1.4 Test Methods for determining the approximate as-conveyed bulk density of the material and for determining the electrical horsepower input of the equipment motors are also included.

1.5 It is intended that the tests be made and reported by personnel trained in the proper application and use of the various instruments and methods involved.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.* For hazard statement, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[2]

E 856 Definitions of Terms and Abbreviations Relating to Physical and Chemical Characteristics of Refuse-Derived Fuel[3]

2.2 *Other Standard:*

No. 550 Classification and Definitions of Bulk Materials[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *oversize bulky waste (OBW)*—items whose large size precludes or complicates processing or sampling.

3.1.2 *performance test*—a test devised to permit observation and measurement of the performance of a system or unit of equipment operating under prescribed load conditions.

3.2 For definitions of other terms used in these test methods, refer to Definitions E 856. For an explanation of the metric system including symbols and conversion factors, refer to Practice E 380.

4. Summary of Test Methods

4.1 The conveying equipment performance can be calculated by determining the volume or weight of a representative sample of material on the conveying equipment and measuring its speed. Another method for calculating the conveying equipment performance is to measure the infeed or discharge weight or volume in a given length of time. The minimum recommended number of test runs and size of samples are provided for various types of materials (see Table 1).

4.2 The material flow rate may be reported in any unit; sample calculations are given only for selected (common) units.

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[1] These test methods are under the jurisdiction of ASTM Committee D-34 on Waste Management and are the direct responsibility of Subcommittee D34.06 on Recovery and Reuse.

Current edition approved March 26, 1982. Published December 1982.

[2] *Annual Book of ASTM Standards*, Vol 14.02.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

[4] Available from Conveyor Equipment Manufacturers Association, 1000 Vermont Ave., N.W, Washington, DC 20005.

4.3 Motor wattage (or amperage and voltage) may be measured and used to calculate the electrical power consumption.

5. Significance and Use

5.1 These test methods may be used to measure the equipment performance.

5.2 These test methods are applicable when the conveying equipment is of sufficient length and is accessible for taking the samples and measuring the speed, or when the discharge is accessible to collect a sample in a given length of time. Not all pieces of equipment in a processing plant may be accessible; therefore, the input or total of inputs to adjacent upstream equipment/output or total of outputs of adjacent downstream equipment may be used to determine the throughput of the conveying equipment in question. Judgement must be used to determine any loss of material or changes in bulk density.

6. Apparatus

6.1 *Ammeter/Voltmeter*—Multimeter or individual meters to permit reading the maximum current and voltage anticipated. Meters may be the snap-on type with analog or digital readout.

6.2 *Bulk Density-Measuring Container*—An open-top container constructed of suitable materials such as plywood or plastic and having the following internal dimensions: 300 mm wide by 300 mm long (1 by 1 ft) and 600 mm (2 ft) high may be used for material normally smaller than 150 mm (6 in.) in size. Suitable handles may be attached to the exterior of the container to aid in subsequent handling.

NOTE 1—Alternatively, containers of other dimensions may be employed provided the base area is known and sides are perpendicular. Dimensions of the container shall be a minimum of two times the largest particle size.

6.3 *Bulk Density Measuring Rod*—A round or square rod, approximately 50 mm (2 in.) in diameter or square by 600 mm (2 ft) long, calibrated in 5-mm (0.1-in.) intervals starting from one end. The end should be cut off square to prevent sinking into sample.

6.4 *Tachometer or Speed Indicator*— A tachometer with linear speed indicator or surface speed indicator. Indicator may be hand type with digital readout.

6.5 *Wattmeter*—Industrial analyzer or individual wattmeter to provide two wattmeter indications for three-phase power. Meters may be analog or digital type.

7. Safety Hazards

7.1 These test methods may involve the use of hazardous materials, operations, and equipment. It is the responsibility of whomever uses this standard to establish appropriate safety practices and to determine the applicability of regulatory limitations prior to use.

7.2 Due to the origins of municipal solid waste, common sense dictates that some precautions should be observed when conducting tests. Recommended hygienic practices include use of gloves when handling the waste, wearing dust masks (NIOSH-approved type), and washing hands before eating or smoking.

7.3 Safety precautions should be taken when measuring conveyor speeds or collecting samples near open, moving equipment and taking electrical measurements.

NOTE 2—**Precaution:** Include use of eye protection and hard hats, avoidance of loose-fitting clothing that could become entangled in machinery, and adopt the use of a" buddy system" in which the person conducting the test is always within sight and hearing of a coworker.

8. Sampling

8.1 *Minimum Number of Tests and Size of Sample*—The minimum recommended number of tests and minimum size of samples to be collected are shown in Table 1, based on the type of material and particle sizes.

NOTE 3—The quantity and size of samples have to be statistically verified. ASTM is conducting additional sampling experiments to verify this information.

8.2 *Frequency of Sample Collection*—No more than one sample shall be taken at a time. After collecting a representative sample, a minimum of 15 min processing time shall elapse before taking the next sample.

9. Procedures

9.1 *General*—Install, lubricate, and align the equipment to be tested in accordance with the manufacturer's recommendations. It is advisable to make one or more preliminary tests for the purpose of determining the adequacy of the instruments and apparatus, and the training of the personnel, if required. Before the tests are begun, run the equipment under stable conditions for sufficient length of time to bring about equilibrium and steady readings.

9.2 *Recording Data*— Keep complete records of all information relevant to the tests. A suggested form for recording the data and calculating the results is given in Fig. 1. Additional observations such as material wetness, particle size variations, unusual constituents in the waste or unusually high concentrations of a particular constituent, and conveying equipment spillage, rollback of material, dusting, etc., should be recorded on the back of Fig. 1 or on a separate sheet. Before removing test equipment, compute the results to determine if they are reasonable. If so, the test can be considered terminated and the test equipment removed.

9.3 *Calibration of Instruments*—Properly calibrate all instruments in accordance with the manufacturer's instructions. Confirm that the instruments are in good condition and are being used under conditions corresponding to those existing at the time of their calibration.

9.4 *Sample Collection on Open Conveyors*—On open conveyors such as apron, belt, drag, and flight conveyors that can be stopped, cut two bulkheads from plywood or similar material to fit the contour of the conveying surface to prevent material rollback. Place these contoured bulkheads on the conveyor to establish sample (gathering) boundary. Stop the conveyor. Place one bulkhead, perpendicular to the length of the conveyor and perpendicular to the conveying surface, making sure the material is separated uniformly. Place the second bulkhead in a similar manner either upstream or downstream from the first, a sufficient distance to obtain one of the recommended size samples from the conveyor. Measure the length between the bulkheads (L_s) to the nearest 10 mm (0.25 in.) and record. Carefully remove all of the material, including the fine, particulate materials, from between the two bulkheads.

Owner's Name ______ Sheet ______ of ______
Plant location ______ Material description ______
Type of Equipment ______ Weather ______
Item. No. ______ Name ______
Arrangement: Horizontal length ______ Height ______ Incline ______ Width ______
Rated capacity ______ Rated bulk density ______ Rated volume ______
Motor Type ______ Frame ______
Manufacturer ______ Serial No. ______
Rated horsepower ______ Rated speed ______ Full load current ______
Characteristics: Voltage ______ Phase ______ Frequency ______
Gear Reducer Type ______ Belt or Chain ______
Manufacturer ______ Serial No. ______
Speed ratio ______ Class ______ Horsepower ______ Service Factor ______

TEST INFORMATION:

(A) *Open Conveying Equipment Feed Performance Determinations:*

Test No.	Sample Weight (W_s)	Sample Volume	Conveyor Speed (*N*)	Sample Length (L_s)	Calculated Capacity (*C*)	Percent Difference from Rated
1						
2						
3						
4						
5						
				Average:		

Make and serial number of instruments/date calibrated ______

(B) *Closed Conveying Equipment Performance Determinations:*

Test No.	Sample Weight (W_s)	Sample Volume	Collection Time (*T*)	Calculated Capacity (*C*)	Percent Difference from Rated
1					
2					
3					
4					
5					
			Average:		

Make and serial number of instruments/date calibrated ______

(C) *Bulk Density Determinations:*

Test No.	Filled Container Weight (W_f)	Empty Container Weight (W_e)	Area of Base (*a*)	Height of Material (*h*)	Calculated Bulk Density (*BD*)	Percent Difference from Rated
1						
2						
3						
4						
5						
				Average:		

Make and serial number of instruments/date calibrated ______

(D) *Electrical Horsepower Input Determinations:*

Test No.	Motor Watts (*W*)	Motor Voltage (*E*)	Motor Amperage (*I*)	Calculated Horsepower (*Ehp*)	Percent Difference from Rated
1					
2					
3					
4					
5					
			Average:		

Make and serial number of instruments/date calibrated ______

Date ______ Test made by ______ Witnessed by ______

FIG. 1 Mechanical Conveying Equipment Suggested Performance Test Data Sheet

Place the sample in adequate container(s) or plastic bag(s) for material where moisture is a factor. If the length of time before measuring the bulk density is to be more than 2 h, it is recommended to use double plastic bags with ends sealed separately to prevent moisture loss or gain. Do not squeeze or compress the sample. Determine the bulk density as soon as possible after collection to prevent drying, moisture gain, or settling.

9.5 *Sample Collection at Equipment Discharge*—On screw conveyors, vibrating conveyors, enclosed conveyors (or otherwise nonaccessible), and bucket elevators or conveyors that cannot be stopped, collect the sample from the discharge. Collect the entire cross section of the discharge in suitable size container(s) or plastic bag(s) for a time period. Do not squeeze or compress the sample. Determine the bulk density as soon as possible after collection. Record the length of time (*T*) required to fill each container to the nearest 1 s.

9.6 *Weighing Sample*—Carefully weigh each sample (W_s) collected above to the nearest 0.05 kg (0.1 lb) using a suitable weighing scale.

9.7 *Measure Conveyor Speed*—Measure the speed of smooth belt conveyors (N) in m/min or ft/min by using a tachometer with surface speed indicator. One alternative method may be by measuring the distance a mark on the conveyor moves in a given length of time. The latter method should be performed a minimum of three times and the average of the three measurements may be recorded as N. (Three measurements is arbitrary to minimize human or other errors.) On metal apron conveyors, the r/min of the headshaft, pitch, and number of teeth in the headshaft sprocket or diameter of drive pulley may be used.

9.8 *Truck Scale Weight/Unit of Time*—As an alternative method of calculating throughput, weigh a quantity of raw refuse using truck weighing scales, if available. Measure the length of time required for processing the weighed quantity to determine the throughput rate.

9.9 *Measuring Bulk Density of Material*[5]—Determine the approximate as-conveyed bulk density for each of the samples collected in accordance with 8.1. Determine the empty weight of the bulk density-measuring container (W_e) by weighing the empty container before each determination to the nearest 0.5 kg (0.1 lb). Carefully fill the measuring container with material that would be representative of the sample, that is, approximately one third from the top, one third from the middle, and one third from the bottom, including fines. Carefully level the surface of the material manually to minimize surface irregularities. Take care not to tamp the material or cause settling so as to maintain as nearly as possible the as-conveyed density. Carefully measure the distance from the top of the container to the surface of the material to the nearest 5 mm (0.1 in.) in each of the four corners of the container using the bulk density measuring rod described in 6.3. Subtract the average of the four measurements from the inside height of the container to determine the height of the material (h). Weigh the filled container to the nearest 0.05 kg (0.1 lb) to determine the filled weight (W_f) of the container plus contents.

9.10 *Measuring Electrical Power*[6]—The electrical power may be measured by using one or two wattmeters to measure the wattage (W) or an ammeter to measure the motor current (I) and a voltmeter to measure the motor voltage (E). These measurements may be made at the motor control center (or starter) terminals. The average measurement of each leg should be used.

NOTE 4—On direct current type motor drives, the power of the controller and blower will be measured as well. Also, power factors are included in the wattmeter methods and are not included in the current and voltage method.

10. Calculation

10.1 Calculate apron, belt, drag, or flight conveyor performance (C) in megagrams per hour using the sample weights and belt speeds in accordance with the following equation:

$$C = [(W_s \times N)/(L_s)] \times 0.06 \quad (1)$$

where:
C = conveyor performance, Mg/h,
W_s = mass of sample collected, kg,
N = speed of conveyor, m/min,
L_s = length of conveyor between bulkheads over which the sample was distributed, m, and
0.06 = conversion factor of min to h and kg to Mg.

10.1.1 To calculate the conveyor performance in short tons per hours, use Eq 1 with pounds and inch measurements and use 0.0025 as the conversion factor.

10.1.2 To calculate the conveyor performance in cubic metres per hours or cubic feet per hour, use Eq 1 with the mass of the sample divided by the bulk density and use 60 (5.0) as the conversion factor.

10.2 Calculate screw conveyor, vibrating conveyors or bucket elevator performance (C) in megagrams per hour using the collected sample weights and measured times of collection in accordance with the following equation:

$$C = (W_s)/(T) \times 3.6 \quad (2)$$

where:
C = conveyor or bucket elevator performance, Mg/h
W_s = mass of collected sample, kg,
T = length of time in seconds required to collect sample, and
3.6 = conversion factor of s to h and kg to Mg.

10.2.1 To calculate the conveyor performance in short tons per h, use Eq 2 with W_s lb and use 1.8 as the conversion factor in place of 3.6.

10.2.2 To calculate the conveyor performance in m^3/h or ft^3/h, use Eq 2 with the volume measurement to the nearest 0.1 m^3(0.1 ft^3) in place of the sample weight and use 3600 as the conversion factor.

10.3 Calculate the bulk density of the sample using the following equation:

$$BD = (W_f - W_e)/(a \times b) \quad (3)$$

where:
BD = bulk density of the material, kg/m^3 (or lb/ft^3),
W_f = weight of measuring container plus material, kg (lb),
W_e = weight of empty measuring container, kg (lb),
a = inside area of container base, m^2 (ft^2), and
h = average inside height of material in container, m (ft).

10.4 Calculate the electrical horsepower input to the drive using either of the following three equations:

10.4.1 Industrial analyzer method of measurement:

$$E_{hp} = W/746 \quad (4)$$

where:
E_{hp} = electrical horsepower input to the drive, and
W = analyzer wattmeter reading, W.

10.4.2 Two-wattmeters method of measurement:

$$E_{hp} = (W_1 + W_2)/(746) \quad (5)$$

[5] A separate method for measuring bulk density is in preparation. When approved, this section will be revised to refer to the new standard.

[6] A separate method for measuring electric power consumption is in preparation. When approved, this section will be revised to refer to the new standard.

TABLE 1 Minimum Number of Test Runs and Sample Sizes for Performance Determination

Type	Description	Normal Top Particle Size, mm (in.)	Number of Test Runs	Sample Size, m^3 (ft^3)
Raw refuse (as discarded)	municipal solid waste; residential, commer- cial, and industrial (excludes oversize bulky waste)	900 (36) max in any one dimension	8	1.5 (50)
Processed Refuse	primary screen undersize	200 (8)	8	0.1 (2)
	primary screen oversize	900 (36) max in any one dimension	8	1.5 (50)
	first-stage shredded refuse	300 (12)	8	0.25 (8)
	air-classified heavy fraction	300 (12)	8	0.25 (8)
	air-classified light fraction	300 (12)	8	0.25 (8)
	second-stage shredded light fraction	100 (4)	8	0.25 (1)
	screened air-classified light fraction	50 (2)	8	0.25 (1)
	densified refuse-derived fuel	40 (1½)	8	0.25 (1)
	pulverized or powdered RDF	10 (⅜)	8	0.25 (½)
Magnetic scrap	first-stage shredded metal	300 (12)	8	0.25 (1)
	light-gage iron scrap after air classification	300 (12)	8	0.25 (1)
	shredded or nuggetized iron scrap	25 (1)	8	0.25 (1)
Nonferrous scrap metal	aluminum can stock	100 (4)	8	0.25 (1)
	shredded aluminum scrap	50 (2)	8	0.25 (1)
	other nonferrous metals	50 (2)	8	0.25 (1)
Mixed glass	coarse cullet glass	75 (3)	8	0.25 (1)
	fine cullet glass	6 (¼)	8	0.25 (1)

where:
E_{hp} = electrical horsepower input to the drive,
W_1 = reading of first wattmeter, and
W_2 = reading of second wattmeter.

10.4.3 Voltage and ammeter method for single phase measurements:

$$E_{hp} = [(E \times I)/746] \times (PF/100) \tag{6}$$

where:
E_{hp} = electrical horsepower input to the drive,
E = average motor voltage, V,
I = average motor amperage, A and,
PF = power factor, %.

10.4.4 For three phase measurements use:

$$E_{hp} = (1.732\, E \times I \times PF)/(746 \times 100) \tag{7}$$

10.5 The calculated feed rates, bulk densities, and electrical horsepower inputs may be compared to the specification values to evaluate equipment performance in the given application. Electrical horsepower input calculation should be used for reference purposes only since drive efficiencies are not included in the above horsepower calculations.

11. Precision and Bias

11.1 Precision and bias have not yet been developed.