INTERNATIONAL

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Standard Test Method for Performance Evaluation of Anaerobic Digestion Systems[1]

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1. Scope

1.1 This test method is applicable to all anaerobic digestion systems.

1.2 *This standard does not purport to address all of the safety problems, 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]

E 1126 Terminology Relating to Biomass Fuels

2.2 *Standard Methods (SM) for Analysis of Water and Wastewater:*[3]

2540 D Total Suspended Solids
2720 B Sludge Digester Gas (Volume)
4500 F NH^{+}_3 Nitrogen (Ammonia)
4500 B Nitrogen (Organic), Total Kjeldahl Nitrogen
5210 B Biochemical Oxygen Demand
5220 B Chemical Oxygen Demand
5520 D Oil and Grease

3. Terminology

3.1 *Definition*—see Terminology E 1126.

3.1.1 *biogas*—a composition of methane and carbon dioxide and minor constituents produced by the digestion of organic substrates in the absence of oxygen.

4. Summary of Test Method

4.1 This test method measures the concentration and mass of the influent and effluent wastes, respectively, as well as other operational parameters such as input energy, output gas production, and waste biomass, to provide a methodology for evaluation of the operation of an aerobic digester.

5. Significance and Use

5.1 This test method will yield data that will form a performance profile for an anaerobic digester facility. The significance of this profile is that it can be compared directly to another facility's performance profile and yield a measurement of expected facility performance under field conditions.

5.2 This test method will also yield data that can be used to verify the operation of a system to a regulatory agency.

5.3 The single black box technique applied to performance evaluation examines only the overall input/output relationship. This implies that the operation of the facility during the tests will be conducted to achieve design conditions in accordance with established procedures.

6. Procedure

6.1 Conduct the test for a predetermined period mutually agreed upon by all parties participating in the testing program. Start the test period when the system manufacturer determines that the system has reached normal operating conditions. Record the time period between the initial loading of the system with waste and the start of the test period. A minimum test period of 90 days is suggested.

6.2 Determine the influent and effluent concentrations of the following, using the methods recommended, total suspended solids (TSS) SM 2540 D, NH^{+}_3 nitrogen (ammonia) (AN) SM 4500 F, nitrogen (organic)-total kjeldahl nitrogen (TKN) SM 4500 B, biochemical oxygen demand (BOD) SM 5210 B, chemical oxygen demand (COD) SM 5220 B, and oil and grease (OG) SM 5520 D. The sampling frequency and location of sampling shall be mutually agreed upon by all parties involved in the project. As a minimum, weekly sampling of a composite sample of 24 h of influent and effluent is suggested.

6.3 Measure the gas production continuously, using SM 2720 B, or equivalent. Analyze the gas compositions using a gas chromatograph (GC) to determine the composition of CH_4. The GC analysis frequency shall be mutually agreed upon by all parties participating in the testing program.

6.4 Measure the thermal energy input. The most common method of thermal energy input is hot water supplied to the system using a heat exchanger. Monitor the energy input on a continuous basis by measuring the flow rate of hot water to the system and the influent and effluent flow temperatures, using the reference procedures and equipment.

[1] This test method is under the jurisdiction of ASTM Committee E48 on Biotechnology and is the direct responsibility of Subcommittee E48.05 on Biomass Conversion.

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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] Available from American Public Health Association, 1015 15th St. N.W., Washington, DC 20005.

6.5 Record the horsepower of any motors connected more than 50 % of the time during a 24 h operation.

6.6 Record the weight of any material removed from the system during the test period.

7. Calculation

7.1 *Data Collection*—See Table 1

7.2 *Data Calculations*—SeeTable 2

7.3 *Data Summary*—See Table 3

8. Precision and Bias

8.1 The precision and bias of this test method are still under evaluation.

9. Keywords

9.1 anaerobic digestion; biogas; biomass; waste treatment

TABLE 1 Data Collection Form for Anaerobic Digestion System Performance Evaluation

(*1*) Date:	________
(*2*) Influent concentrations, mg/L	
Total suspended solids (TSS)	________
Ammonia nitrogen (AN)	________
Total Kjeldahl nitrogen (TKN)	________
Biochemical oxygen demand (BOD)	________
Chemical oxygen demand (COD)	________
Oil and grease (OG)	________
(*3*) Effluent concentrations, mg/L	
Total suspended solids (TSS)	________
Ammonia nitrogen (AN)	________
Total Kjeldahl nitrogen (TKN)	________
Biochemical oxygen demand (BOD)	________
Chemical oxygen demand (COD)	________
Oil and grease (OG)	________
(*4*) Cumulative system parameters measured during test	
Volume of waste processed, gal	________
Waste density, lb/gal	________
Volume of biogas produced, ft^3	________
Biogas methane content, weight %	________
Solids wasted from reactor, gal	________
Heating water supplied, gal	________
Heating water supply temperature, °F	________
Heating water return temperature, °F	________
Total continuous horsepower, hp	________
Chemicals added, name of chemical	________
Chemicals added, lb	________
Brief description of facilities included in test program.	________
Data recorded by: ____________________	

TABLE 2 Performance Calculation Procedures

	Calculation Results	
(*1*) Influent mass calculations		
$TSSM_I$	$= TSS_I \times WF \times WD$	_____lb
ANM_I	$= AN_I \times WF \times WD$	_____lb
$TKNM_I$	$= TKN_I \times WF \times WD$	_____lb
$BODM_I$	$= BOD_I \times WF \times WD$	_____lb
$CODM_I$	$= COD_I \times WF \times WD$	_____lb
OGM_I	$= OG_I \times WF \times WD$	_____lb
(*2*) Effluent mass calculations		
$TSSM_E$	$= TSS_E \times WF \times WD$	_____lb
ANM_E	$= AN_E \times WF \times WD$	_____lb
$TKNM_E$	$= TKN_E \times WF \times WD$	_____lb
$BODM_E$	$= BOD_E \times WF \times WD$	_____lb
$CODM_E$	$= COD_E \times WF \times WD$	_____lb
OGM_E	$= OG_E \times WF \times WD$	_____lb
(*3*) Pollutant reduction		
Total suspended solids reduction	$= (TSSM_E - TSSM_I)/TSSM_I$	_____ %
Ammonia nitrogen reduction	$= (ANM_E - ANM_I)/ANM_I$	_____%
Total Kjeldahl nitrogen reduction	$= (TKNM_E - TKNM_I)/TKNM_I$	_____%
Biochemical oxygen demand reduction	$= (BODM_E - BODM_I)/BODM_I$	_____%
Chemical oxygen demand reduction	$= (CODM_E - CODM_I)/CODM_I$	_____%
Oil and grease reduction	$= (OGM_E - OGM_I)/OGM_I$	_____%
(*4*) Energy balance		
Net energy balance	$= (BP \times BMC \times a)$ $-(HWS \times b \times (HWST - HWRT))$ $-(TCHP \times c \times d \times e)$	___Btu

Where:

TSS	= total suspended solids concentration, mg/L
AN	= ammonia nitrogen concentration, mg/L
TKN	= total Kjeldahl nitrogen concentration, mg/L
BOD	= biochemical oxygen demand, mg/L
COD	= chemical oxygen demand, mg/L
OG	= oil and grease concentration, mg/L
TSSM	= total suspended solids mass, lb
ANM	= ammonia nitrogen mass, lb
TKNM	= total Kjeldahl nitrogen mass, lb
BODM	= biochemical oxygen demand mass, lb
CODM	= chemical oxygen demand mass, lb
OG	= oil and grease mass, lb
X_I	= influent value of Parameter X
X_E	= effluent value of Parameter X
WF	= waste flow, gal[A]
WD	= waste density, lb/gal
BP	= volume of biogas produced, ft^3 [A]
BMC	= biogas methane content, %
HWS	= heating water supplied, gal
HWST	= heating water supply temperature, °F
HWRT	= heating water return temperature, °F
TCHP	= total connected horsepower
a	= 1000 Btu/ft^3, typical methane higher heating value
b	= 8.32 lb/gal, water density[A]
c	= 0.74 kW/hp, energy conversion
d	= 24 h/day, typical operation
e	= 10 500 Btu/kWh, optimum efficiency of coal-fired steam electric power plant

Sample calculation:
Assume the following:

Influent parameters:	TSS_I	= 1200 mg/L; AN_I = 30 mg/L; TKN_I = 50 mg/L;
	BOD_I	= 1200; COD_I = 2400; and OG_I = 600 mg/L
Effluent parameters:	TSS_E	= 200 mg/L; AN_E = 40 mg/L; TKN_E = 40 mg/L;
	BOD_E	= 200; COD_E = 400; and OG_E = 100 mg/L
System parameters:	WF	= 1 000 000 gal; WD = 8.32 lb/gal;
	BP	= 1000 ft^3; BMC = 75 %; SW = 0 gal;
	HWS	= 5000 gal; HWST = 120°F; HWRT = 95°F; and
	TCHP	= 15 hp

(*1*) Influent mass calculations		
$TSSM_I$	$= 1200 \times 1\,000\,000 \times 8.32$	lb
ANM_I	$= 30 \times 1\,000\,000 \times 8.32$	lb