Designation: E 869 – 93 (Reapproved 1998)

Standard Test Method for Performance Evaluation of Fuel Ethanol Manufacturing Facilities[1]

This standard is issued under the fixed designation E 869; 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 performance characteristics of fuel ethanol manufacturing facilities.

1.2 This test method is applicable for all starch, sugar, and combination starch/sugar based fermentable feedstocks.

1.3 This test method is applicable to both batch and continuous fuel ethanol manufacturing processes.

1.4 *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]

D 1826 Test Method for Calorific Values of Gases in Natural Gas Range by Continuous Recording Calorimeter

D 2382 Test Method for Heat of Combustion of Hydrocarbon Fuels by Bomb Calorimeter (High-Precision Method)

D 2458 Flow Measurement of Water[3]

D 3286 Test Method for Gross Calorific Value of Coal and Coke by the Isothermal Bomb Calorimeter

D 3590 Test Method for Total Kjeldahl Nitrogen in Water

E 100 Specification for ASTM Hydrometers

E 711 Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter

E 870 Test Methods for Analysis of Particulate Wood Fuels

2.2 *Association of Official Analytical Chemists (AOAC) Standards:*[4]

10.231 Test for Moisture in Brewers Grains

14.062 Test for Moisture in Wheat, Rye, Oats, Corn, Buckwheat, Rice, Barley, and Soybeans and their Products Except Cereal Adjuncts

14.073–14.074 Test for Starch in Cereals

31.005–31.008 Test for Moisture in Sugars

31.051 Test for Glucose in Sugars and Syrups

31.056 Test for Fructose in Sugars and Syrups

31.060 Test for Maltose in Sugars and Syrups

31.062 Test for Lactose in Sugars and Syrups

2.3 *Standard Methods (SM) for Analysis of Water and Wastewater:*[5]

206 B Test for Fats, Oils, and Grease

209 C Test for Total Suspended Solids

507 Test for Biochemical Oxygen Demand, Five Day (BOD_5)

3. Terminology

3.1 *Definitions:*

3.1.1 *cycle time*—the time required by an alcohol plant to complete one cycle. The determination of the cycle time for a batch process is illustrated in Fig. 1 and for a continuous process in Fig. 2.

3.1.2 *normal operating conditions*—the usual range of physical conditions for which a facility was designed to operate.

3.1.3 *production cycle*—the series of operations required to process through the facility a quantity of feedstock mixed with water having a volume equal to the typical volume of the fermentation system and return the facility to the configuration at the start of the cycle. The quantity of water mixed with the feedstock shall be as per specification for normal operation. This volume is equal to the sum of the working volumes of all fermenters in a batch fermentation process. This volume is equal to the sum of the working volumes of each stage of fermentation in a continuous fermentation process. The determination of the production cycle for a batch process is

[1] This test method is under the jurisdiction of ASTM Committee E-48 on Biotechnology and is the direct responsibility of Subcommittee E48.05 on Biomass Conversion Systems.

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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] Withdrawn.

[4] Available from Association of Official Analytical Chemists, 1111 N. 19th St., Arlington, VA 22209.

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

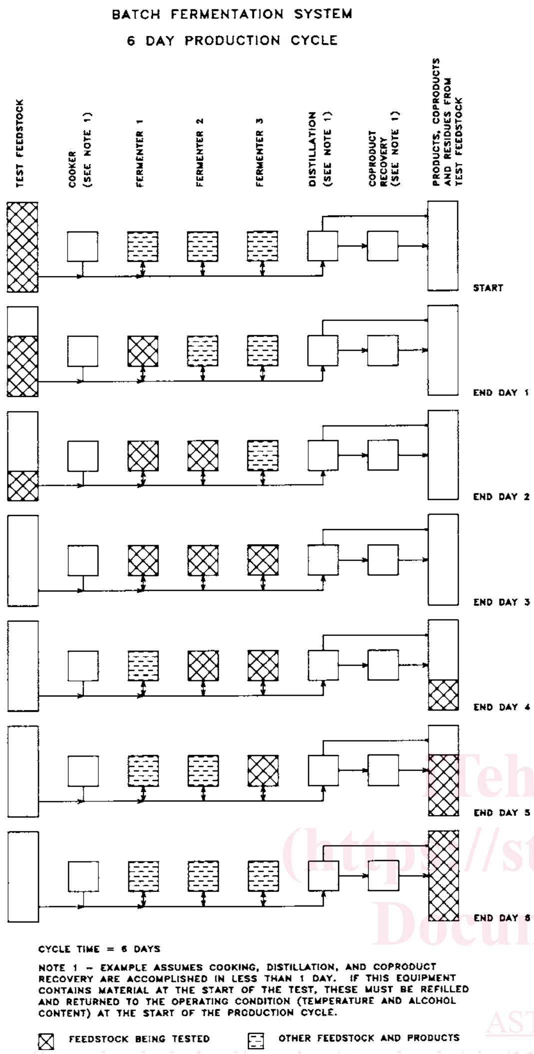

FIG. 1 Production Cycle and Cycle Time for Batch Process 6 Day Production Cycle

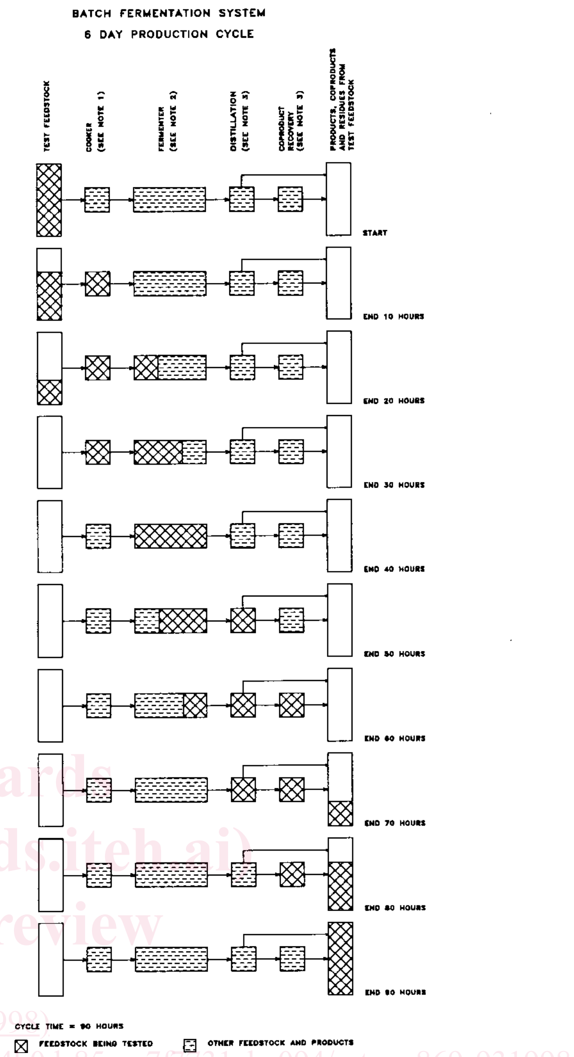

FIG. 2 Production Cycle and Cycle Time for Continuous Process 90 h Production Cycle

illustrated in Fig. 1 and for a continuous cycle in Fig. 2. Any differences in the configuration between the start and end of the test shall be noted in Table 1.

4. Summary of Test Method

4.1 A fuel ethanol manufacturing facility's performance shall be characterized by four main parameters. These are (*1*) conversion efficiency, (*2*) energy for conversion, (*3*) production rate, and (*4*) mass balance. This test method shall establish the procedures required to measure, interpret, and assign values for these parameters. This test method shall consider each facility as a single "black box" and, for the purpose of these procedures, a description of the black box shall be established and recorded prior to testing. This black box may include systems for feedstock preparation, conversion of carbohydrates to alcohol, and separation of alcohol and co-products.

4.2 *Conversion Efficiency*—This parameter represents the facility's capability to convert a feedstock into fuel ethanol. This shall be expressed as the ratio of the actual fuel ethanol yield per unit mass of dry feedstock to theoretical fuel ethanol yield per unit mass of dry feedstock.

4.3 *Energy for Conversion*—These parameters (electrical, thermal, and total energy) reflect the energy required to run the facility. These shall be expressed as a ratio of the electrical, thermal, and total energy required for production of a given volume of fuel ethanol to the volume of fuel ethanol produced (in moisture-free fuel ethanol).

4.4 *Production Rate*—This parameter of performance expressed the facility's ability to convert a feedstock to fuel ethanol during a specified unit of time. Since this test method shall apply to a large variety of facility sizes and configurations, this parameter can be expressed as the total volume of fuel ethanol produced (on a moisture-free basis) divided by the cycle time as defined in 3.1.1.

4.5 *Mass Balance*—This performance parameter measures the facility's production of fuel ethanol and other co-products. This shall be represented as a mass ratio of these products to the feedstock all on a moisture-free basis.

5. Significance and Use

5.1 This test method shall yield data that will form a "performance profile" for a fuel ethanol manufacturing facility.

TABLE 1 Data Collection Form for Fuel Ethanol Plant Performance Evaluation

(*1*) Plant cycle date and time	
(Record for each cookbatch)	
Start:	
Finish:	
(*2*) Plant conditions at test start	
Cooker:	
Volume	
Temperature	
Alcohol proof of contents	
Fermenters (repeat for each unit):	
Volume	
Temperature	
Alcohol proof of contents	
Distillation:	
Volume	
Temperature	
Alcohol proof of contents	
Co-product recovery:	
Volume	
Temperature	
Alcohol proof of contents	
(*3*) Feed stock	
Type:	
Analysis:	
Moisture, wt %	
Starch, wt %	
Glucose, wt%	
Fructose, wt %	
Maltose, wt %	
Lactose, wt%	
Density, lb/unit volume	
Quantity used during cycle, units	
(*4*) Water added to process	
Fresh water, gal/°F	
Setback (recycle) water, gal/°F	
Alcohol content, proof	
Biochemical oxygen demand (BOD), mg/L	
Total suspended solids (TSS), mg/L	
Fats, oils, and grease (FOG), mg/L	
Alcohol proof	
(*5*) Enzymes yeast, process chemicals used—list separately	
Type, quantity	
(*6*) Alcohol produced	
Product recovered, gal	
Proof (adjusted to 60°F)	
Temperature, °F	
Losses:	
Thin stillage, flow/proof	
Spent solids, flow	
Wt % alcohol	
(*7*) Distillers grains recovered	
Quantity, lb	
Analysis:	
Moisture, wt %	
Protein, wt%	
Starch test, Positive/Negative	
(*8*) Energy consumed	
Electrical meter reading (kWh)	
Start	
Stop	
Fuel (Type:) Units	
Start	
Stop	
(*9*) Process wastewater	
Discharge temperature, °F	
Quantity, gal	
BOD, mg/L	
TSS, mg/L	
FOG, mg/L	
(*10*) Plant conditions at test finish	
Cooker:	
Volume	