Specialty Coffee Association

Prepared by the Specialty Coffee Association

# Competition Espresso Machines: Specifications & Test Methods (2021 Edition)

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## 1. Preface

This document is derived from the 2017 WCE requirements for the espresso machines used in barista competitions, revised in 2019 and adapted to the SCA standards format. It covers the requirements for competition espresso machines.

## 2. Scope

This document covers the specifications and test methods for espresso machines to be used at WCC/WCE sanctioned events.

## 3. Normative References

There are no normative references for this document.

## 4. Terms and Definitions

**Automatic espresso machine**. An espresso machine in which brewing is initiated manually, but terminated automatically when a set volume of brew has been produced or when a set brewing time has passed.
**Coffee cake.** The bed of ground coffee placed on the filter (and usually tamped), through which water passes in an espresso machine to produce espresso.
**Espresso**. A thick, concentrated coffee, brewed under pressure. Espresso is generally thicker than coffee brewed by other methods, has a higher concentration of suspended and dissolved solids, and has crema on top (a foam with a creamy consistency). As a result of the pressurized brewing process, the flavors and chemicals in a typical cup of espresso are very concentrated.
**Espresso machine**. A machine which brews coffee by forcing pressurized water near boiling point through a coffee cake and a filter in order to produce espresso.
**Filter basket** (Espresso basket). A component of manual, semi-automatic or volumetric espresso machines that serves as the container for the ground coffee during extraction. The bottom of the basket features finely stamped or machined holes that allow the extracted coffee to exit while retaining the grounds.
**Group/Group Head**. An assembly of static and dynamic components that receives the portafilter and delivers brewing water to the coffee bed at a preset temperature and flow rate. It is also known as a brew unit or pouring unit.
**Manual espresso machine** (lever espresso machine). An espresso machine in which the pressure necessary for brewing is generated through a hand-operated lever.
**Non-automated steam wand**. The steam wand for which steaming is initiated and terminated manually, by human actuation of a mechanical or electro-mechanical device, such as an actuation lever, knob, or foot pedal.
**Portafilter**. A removable, handheld component of a manual, semi-automatic or volumetric espresso machine, that performs the function of retaining the filter basket and securing it into the group head during the extraction process. It includes a pouring spout to direct the flow of coffee into a container. A bottomless or "naked" portafilter has the bottom portion of the portafilter and spout removed to expose the bottom of the espresso brew basket.
**Semi-automatic espresso machine**. An espresso machine in which brewing is initiated and terminated manually, by human actuation of a mechanical or electro-mechanical device, such as a push-button.
**Spigot** (Hot Water Spigot/Hot Water Spout). A spout typically found above the drip tray of a manual, semi-automatic or volumetric espresso machine that dispenses hot water for a variety of purposes.
**Steam wand**. A tubular component that is designed to introduce heat and texture to milk or similar liquids. It is often made with stainless steel, Teflon coating or brass plating and has a removable tip with a series of small holes for controlling the direction and force of the steam.
**Steam Wand Valve Assembly.** A component on espresso machines that controls the flow of steam from the boiler to the steam wand, either by a control lever, knob, or electro-mechanical solenoid and switch.
**Superautomatic espresso machine**. An espresso machines which grinds whole beans that are put into the

machine and deposits the grounds into the brew group, where they will be tamped and brewed. The user chooses the liquid volume that is dispensed using controls on the machine.
**WCC**. World Coffee Championships, produced by World Coffee Events.
**WCE**. World Coffee Events, the SCA's event management organization.

## 5. Classification

By Degree of Automation

Espresso machines covered by this document may be semi-automatic or automatic.

## 6. Specifications

The specifications for Competition espresso machines are described in Table 1. In addition, espresso machines should operate reliably during testing.

*Table 1. Specifications of Competition Espresso Machines*

| Specification | Competition Espresso Machine | Test Method |
|---|---|---|
| Number of groups | 3 | Verification |
| Automation | Semi-automatic or automatic with the capability to operate as semi-automatic | Verification |
| Number, characteristics and location of steam wands | 2, non-automated, one near each end of machine | Verification |
| Hot water spigot | Present | Verification |
| Brew Temperature Reproducibility (Individual Group) | Maximum temperature deviation shall be twice the standard deviation of all 14 average brew temperatures obtained in the test series | 7.3 |
| Temperature Consistency | Average brew temperature (as defined in A.5.2) of between 90.5 and 96 C, with a maximum individual group brew temperature reproducibility (per A.5.3) of 1.1 C. | 7.3 |
| Maximum Inter-Group Temperature Consistency | 1.1 C | 7.3 |
| Pressure difference | Maximum Δ of 0.4 bar (6 psi) in 9 measurements. The machine shall perform reliably, without a gross change in pressure ramping (Δ ≤ 0.4 bar) when operating multiple groups compared to one group. | 7.4 |
| Outcoming brew concentration | 9-15% Total Dissolved Solids | 7.5 |
| Outcoming extraction yield | 18-22% | 7.5 |

## 7. Equipment Submission and Test Methods

Requirements of Espresso Machines and Parts Submitted for Testing
Espresso machine manufacturers shall submit the following items to the testing laboratory for testing: espresso machine (one 3-group machine of each brand/model), and five (5) portafilters.

### 7.1. Water Supply Information

During testing, the espresso machine will draw brewing/steaming water from a bottled water supply, and discharge wastewater to a drain bucket.

### 7.2. Electrical Supply Information

Submitted espresso machines shall operate at 230V, 50Hz or at 400V triphasic plus neutral, depending on the specific testing lab requirements, which will be communicated in advance to testing.

### 7.3. Submission of Portafilters

Five (5) portafilters shall be submitted, of which three (3) shall be supplied with double-spouts and two (2) shall be modified such that the floor of the portafilter is machined away (bottomless configuration). The inside diameter of the bored-out floor shall be the same as that of the portafilter body. These two bottomless portafilters will be used for quantitative temperature and pressure testing. Portafilters as provided on the submitted machines shall have as internal depth sufficient to house a filter with 20g nominal capacity. The nominal diameter of the portafilters (e.g., 58mm, 57mm, 54mm, etc.) shall be disclosed.

### 7.4. Installation

The manufacturer is responsible for installing the machine prior to the tests, and insuring that the machine performs to the manufacturer's satisfaction. The manufacturer (or its agent) shall supply and install all necessary equipment to connect the espresso machine to the water source and drain, including pumps required to meet the espresso machine's inlet pressure requirement, accumulator tanks, all tubing and fittings.

### 7.5. Operation/Maintenance/Repair

It is the manufacturer's responsibility to ensure that the espresso machine's operational parameters are within the SCA standards of these tests, and that the machine operates as expected by the manufacturer. The manufacturer is responsible for maintenance and repair of its espresso machine during the tests. This includes all the equipment required.

### 7.6. Machine Removal

Manufacturers shall be responsible for draining, decommissioning, packing, and transporting their machinery after testing is concluded, and shall supply all required equipment and personnel for this purpose.

### 7.7. Manufacturer's responsibilities during testing process

#### 7.7.1. Preparation for Testing

Prior to quantitative testing, the manufacturer shall ensure that its candidate espresso machine is adjusted such that temperature and pressure fall within the values specified in Table 1, as applicable. The manufacturer of a candidate machine may specify a preference with respect to the position of the group flush within the workflow: at the removal of the portafilter from the group, or immediately before reinsertion. The manufacturer may specify and perform group flushing during the 10-minute window that enhances the response time of the machine (see A.4.5).

#### 7.7.2. Adjustment during Testing

Adjustments to temperature and pressure during a machine's quantitative temperature and pressure testing are only allowed per the testing requirements, or with the permission of the testing committee chair and consensus of the testing committee.

#### 7.7.3. Access to Internal Components

The manufacturer's designated service personnel shall provide access to internal components of the respective candidate espresso machines as requested by members of the testing committee.

### 7.8. Testing Methods

#### 7.8.1. Quantitative Temperature Testing

Tests shall be performed per the *Appendix: Method for the Measurement of Brewing Water Temperature in Espresso Machines*. Tests shall be performed on multiple groups operating simultaneously: Groups 1 and 2; 1 and 3; 2 and 3. Response to step changes in temperature will be measured. An arbitrary pair of groups should be retested with simultaneous steam actuation.

#### 7.8.2. Quantitative Pressure Testing

Pressure measurement shall be performed at the groups, under the flow conditions specified in the Appendix: Method for the Measurement of Brewing Water Temperature in Espresso Machines. Measurements will be obtained on each individually operating group, and on combinations of simultaneously operating groups: Groups 1 and 2; 1 and 3; 2 and 3.

#### 7.8.3. Extraction Testing

Two randomly selected baskets will be used for extraction testing, for which a series of extractions will be pulled at brewing ratios (the ratio of the weight of ground coffee to weight of brewed espresso) between 50 and 80%. At the testing site, the percent concentration and extraction yield shall be determined by plotting measurements obtained with a coffee refractometer on a brewing control chart of concentration vs. extraction yield. The chemical makeup of the brewing water shall conform to SCA standards for water quality.

## 8. Results and Their Confidentiality

All espresso machines complying with the quantitative requirements are eligible for WCC sponsorship consideration. Additionally, complying machines are qualified to license the SCA Certified Espresso Machine mark for a 3-year period. Results may be discussed among members of the testing committee, but they must not be disclosed publicly. Manufacturers are entitled to a copy of their respective results only. They may discuss them publicly.

# Appendix: Method for the Measurement of Brewing Water Temperature in Espresso Machines

### A.1. Measurement Location

The temperature of the brew water shall be measured within the volume below the housing that supports the portafilter, e.g., the brew head, and immediately above the packed bed of coffee, or coffee cake. The location of the temperature probe shall be off center, approximately 1/3 of the distance from the center of the volume to the inner edge of the filter basket. During measurement, the sensing portion of the probe shall only contact water.

### A.2. Measurement Equipment

A fast-responding, electronic temperature probe, positioned as described in section A.1, senses the temperature of the water. The probe shall be mounted in a modified portafilter and filter basket, so that the probe may be conveniently inserted in different machines. For ease of use, measurement consistency, and to ensure that the probe contacts only water, the coffee cake shall be replaced by a proxy cake. The flow rate of pressurized water through the portafilter should be established by a valve, or another metering device. The temperature data shall be read using a suitable readout device, or a data logger. An example of the intended measurement system is depicted in Figures 1-3

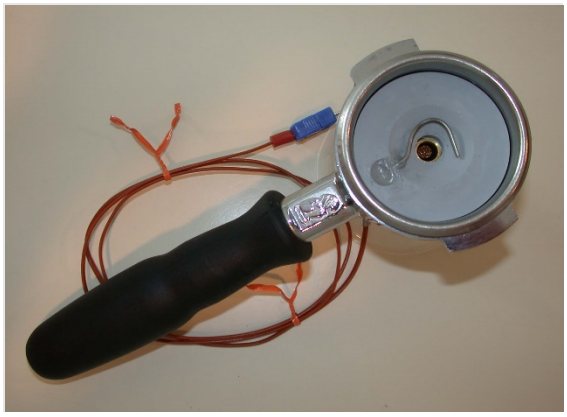

*Figure 1. Portafilter thermometer top view, showing the type T thermocouple probe and the coffee cake facsimile*

*Figure 2. Portafilter thermometer side view showing the thermocouple probe's exit through the bottom of the portafilter, and the brew water metering orifice.*


*Figure 3. Installed portafilter thermometer measuring the temperature of the metered brew water stream.*

### A.2.1 Temperature Sensor

The sensor shall be a type T thermocouple probe, with a response time of less than 0.25 seconds in water.

### A.2.2 Probe Installation

The probe shall be permanently installed in a filter basket, which shall be fitted to an appropriate portafilter for the machine under test. The sensor sheath shall be thermally anchored to the filter basket to minimize heat conduction down the sheath of the probe into the room environment. Portafilter may be modified so that the bottom of the filter basket is open to the room (so-called "bottomless", "naked" portafilter).

### A.2.3 Simulation of the Coffee Cake

The volume of the filter basket normally filled by the coffee cake shall be filled with a proxy cake having a thermal conductivity of less than 0.5 Watts/(meter · Kelvin) (W m-1 K-1). The volume of the proxy cake should be approximately the same volume as a coffee cake, but may contain deviations from the actual shape of the coffee cake in order to accommodate the temperature probe, metering valves, etc. The distance between the group dispersion screen and the top of the proxy cake (headspace) should approximate the headspace in the presence of an actual coffee cake.

### A.2.4 Water Flow Rate Adjustment

A water flow regulator, positioned downstream of the thermometer probe, shall simulate the flow resistance of the coffee cake and provide flow rate regulation as specified in Section A.3.3.

### A.2.5 Data Acquisition

A thermocouple readout device shall measure the voltage generated by the thermocouple probe. Permissible readout devices include electronic thermometers that automatically calculate temperature, or meters such as digital multimeters, provided that a suitable thermocouple reference junction is employed. The preferred method of recording the data is by data logger and computer. Data taken automatically should be acquired at a rate of at least one reading per second.

## A.3. Preparation for testing

### A.3.1 Machine cleanliness

The group(s) shall be back flushed prior to performing the tests. If the dispersion screen(s) is removable for servicing, then it shall be removed, cleaned, and reinstalled. After backflushing, the machine shall remain idle until it has again reached thermal equilibrium as specified in section A.3.2.

### A.3.2 Espresso Machine Thermal Equilibration

The espresso machine to be tested shall be at its normal operating temperature for 1 h prior to testing (the warm-up period). The portafilter containing the thermometer shall be inserted into the group during the warm-up period.

### A.3.3 Adjustment of Brew Water Flow Rate

The flowrate of water through the measurement portafilter shall be measured by weight and shall be adjusted so that 52 g of water is collected in an elapsed time of 25 s ± 3 s.

### A.3.4 Steaming Performance

For the steam performance testing, the elapsed time required to steam 300 cm3 of milk shall be measured. A normal dial-type frothing thermometer shall be immersed in the milk-filled steaming pitcher. Steaming shall continue until the temperature reaches 60 C.

## A.4. Testing

The test procedure measures brew water temperature at gradually increasing frequency, obtaining temperature data over a variety of duty cycles. By slowly decreasing the interval between measurement sets, the influence of duty cycle on various espresso machine designs may be studied. The measurements may be performed with or without steaming, depending on the section of the test. The long idling period of ten minutes prior to the first test run should minimize any effects of pre-test equipment setup.

### A.4.1 Test Procedure

A. **Simulated Idle Period:** The machine shall remain idle with the test portafilter installed into the group for the prescribed period of time between measurements.
B. **Simulated Disposal of Coffee Cake, Dosing and Tamping:** The portafilter shall be removed from the machine, drained of excess water (inversion is sufficient), then reinserted into the group 25 s after removal. The group flush shall be incorporated within this time window.
C. **Group flush:** The required group flush may occur either at the removal of the portafilter from the group, or immediately before reinsertion, as specified by the manufacturer. Since either workflow option is likely to be encountered in operation, either option is permissible during these measurements. However, the order of workflow is to be consistent throughout the measurement series. Regardless of position, the flush shall be no longer than 2 s.
D. **Temperature Measurement of Simulated Brewing:** Measurement shall commence upon reinstallation of the portafilter. The brew process shall be activated either manually or automatically, in the manner appropriate to the machine. Measurements shall be observed and recorded over an approximate time interval of 25 s.
E. **Data Recording:** During the simulation, the temperature shall be observed and recorded manually, or by computer and data logger (preferred method).

### A.4.2 Testing Pattern

The length of the idle interval for item A.4.1. (A) shall be:

*Table 2. Length of the Idle Interval during Temperature Testing*

| Test Point | Idle Interval (mm:ss) |
|---|---|
| 1 | 10:00 |
| 2 | 5:00 |
| 3 | 2:00 |
| 4 | 1:00 |
| 5 | 1:00 |
| 6 | 0:30 |
| 7 | 0:30 |
| 8 | 0:10 |
| 9 | 0:10 |
| 10 | 0:10 |
| 11 | 0:10 |
| 12 | 0:10 |
| 13 | 0:10 |
| 14 | 0:10 |

### A.4.3 Number of Groups to be Tested

Individual or multiple groups may be tested. Multiple groups should be tested in combinations (Groups 1 and 2; 1 and 3; 2 and 3) and in any portafilter insertion order, including nominally simultaneous insertion.

### A.4.4 Test Procedure Including Effects of Steaming Milk

A data point of the test procedure shall be performed with the inclusion of simulated steaming. For this, the steam valve shall be opened in Step A.4.1. (C) of the procedure, after initiating brewing. The steam tip shall be immersed in water and opened for the amount of time determined in Section A.3.4.

### A.4.5 Temperature Adjustment Response Time Testing

The time response of espresso machines to step changes in temperature set point shall be tested, to determine if temperature equilibrium can be achieved within a sufficiently short time window to enable brewing temperature adjustment per competitor specification during the setup phase of competition. A temperature set point change of 2 C shall be initiated by either the testing personnel or the manufacturer's representative. After 10 minutes have elapsed, test points 9 through 14 from the test pattern in Table 2 shall be performed. The manufacturer may specify and perform group flushing during the 10-minute window that enhances the response time of the machine. Multiple groups may be tested per A.4.4.

## A.5. Interpretation of Results

### A.5.1 Identification

The manufacturer, model and serial numbers, number of groups, and the date of the test shall be recorded. Specific operating conditions shall be noted, e.g., one or more groups in operation, with or without steaming, etc. Other pertinent identifying remarks, such as boiler configuration (dual boiler, heat exchanger), or group type should be noted.

### A.5.2 Average Brew Temperature of a Brew Cycle

The average brew temperature shall be expressed in one of two ways, depending on whether the data is collected manually or automatically by data logger. In the case of manual data collection, the

average brew temperature shall be the temperature observed most often during a specific simulated brew cycle, ignoring temperature observations during the first three seconds of the cycle (ignoring results during the first three seconds negates the effect of thermometer lag on the result). For automatic data collection, the average brew temperature shall be the average of all temperature readings during the brew cycle except for those occurring in the first three seconds.

**A.5.3 Brew Temperature Reproducibility (Individual Group)**
The brew temperature reproducibility is the ability of an espresso machine to produce brewing water at the same average temperature over a variety of use conditions. This information may be calculated from manually collected or computer collected data. Average brew temperature is defined in A.5.2.

**A.5.4 Inter Group Temperature Consistency**
Inter-group temperature consistency is defined as the ability of all groups to provide the same brewing temperature. This value is obtained as follows:

i. Calculate averages of the 14 average brew temperatures obtained per A.5.2 in each test series performed per A.4.2.
ii. Inter-group temperature consistency shall be the difference between the lowest and highest value obtained in step (i).

**A.5.5 Minimum Performance Criteria**
Response to temperature set point step changes (A.4.5) will be assessed for achievement of equilibrium within the time window in A.4.5.

**A.5.6 Espresso Machine Temperature Profile Reproducibility**
The measurement procedure is neutral on the question of optimum brew temperature profile, defined as the time-dependent deviation from the average brew temperature during the course of a brew cycle. Regardless of the profile, the espresso machine should be able to reproduce the profile under a variety of duty cycles. The profile may be evaluated graphically, in which case profile reproducibility shall be reported.

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