Specialty Coffee Association

SCA Standard 350-2021

Semi-automatic and Automatic Espresso Machines:

Specifications and Test Methods

SCA Coffee Equipment Series

Contents

Semi-automatic and Automatic Espresso Machines: Specifications and Test Methods

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Semi-automatic and Automatic Espresso Machines: Specifications and Test Methods

01. Preface
This SCA standard is derived from the World Coffee Events (WCE) requirements for the espresso machines used in barista competitions. It covers the requirements for competition espresso machines ("Competition Grade") and general requirements for espresso machines to be used in cafés and coffee shops ("Café Grade").

02. Scope
This standard covers the specifications and test methods for both automatic and semi-automatic espresso machines, to be used either in cafés/coffee shops or at the World Coffee Championships (WCE-sanctioned barista competitions). Super-automatic espresso machines and manual espresso machines are excluded from this standard.

03. Normative References
There are no normative references for this standard.

04. 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.

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 puck and a filter 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 by 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.

Puck (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.

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.

Spout (hot water spigot/hot water spout). A tube protruding from the espresso machine, 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 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.

Super-automatic espresso machine. An espresso machine 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 Specialty Coffee Association's event management organization.

05. Classification

5.1 By Number of Groups
Espresso machines covered by this standard may have one (1), two (2), three (3), or four (4) groups.

5.2 By Degree of Automation
Espresso machines covered by this standard may be semi-automatic or automatic.

5.3 By Intended Use
Espresso machines covered by this standard may be intended for use in WCC/WCE sanctioned events—"Competition Grade"—or for use in cafés and coffee shops—"Café Grade." The Competition Grade specifications are stricter than Café Grade specifications. Therefore, Competition Grade espresso machines meet and/or surpass the specifications of Café Grade espresso machines.

06. Specifications

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

Table 1: Specifications of Café Grade and Competition Grade Espresso Machines

Specification	Café Grade Espresso Machine	Competition Grade Espresso Machine	Test Method
Number of groups	2, 3, or 4	3	7.1
Automation	Semi-automatic or Automatic	Semi-automatic or automatic with the capability to operate as semi-automatic	7.1
Number, characteristics, and location of steam wands	One (1) or more, non-automated and near end of machine	Two (2), non-automated, one near each end of machine	7.1
Hot water spout	Present		
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 1.5°C.	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	1.5°C	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%		7.5
Outcoming extraction yield	18-22%		7.5

07. Equipment Submission and Test Methods

7.1 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 machine of each combination of brand/model and number of groups), five (5) portafilters, and five (5) to (9) filter baskets for machine tests as specified in 7.1.4.

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.

1. **Electrical Supply Information**
   Submitted espresso machines shall operate either at 230 V, monophasic, 50 Hz or at 400 V, triphasic plus neutral.

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 20 g nominal capacity. The nominal diameter of the portafilters (e.g., 58 mm, 57 mm, 54 mm, etc.) shall be disclosed.

4. **Filter Baskets Submission**
   Candidate machine manufacturers shall equip their machines with filter baskets with a nominal capacity of 20±1 g of coffee ground for espresso Adequate headroom above the dose should be provided such that when the portafilter with basket and 20 g dose is mounted to the group assembly, the top of the tamped coffee bed is not disturbed. Four (4) of the filter baskets shall be modified with testing fixtures as per A.2. Candidate machine manufacturers may supply their own modified filter baskets complying with A.2. Candidate machine manufacturers submitting espresso machines using filter baskets with diameters other than 58 mm who do not opt to supply modified filter baskets for testing shall instead supply four (4) filter baskets for the construction of testing fixtures, with basket depth of 27 mm.

5. **Installation**
   The manufacturer may be required to install the machine prior to the tests, ensuring that the machine performs to the manufacturer's satisfaction, in which case 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.

6. **Operation/Maintenance/Repair**
   It shall be 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. Even if not present in person, the manufacturer shall be ultimately responsible for maintenance and repair of its espresso machine during the tests. This includes all the equipment required.

7. **Machine Removal**
   Manufacturers may be required to drain, decommission, pack, and transport their machinery after testing is concluded, and shall supply all required equipment and personnel for this purpose.

Table 2: Group combinations to be tested for brewing temperature and pressure, according to number of groups in espresso machine

Number of groups in espresso machine	Group combinations to be tested simultaneously
2	1 & 2
3	1 & 2; 1 & 3; 2 & 3
4	1, 2 & 3; 2, 3 & 4; 1, 2 & 4; 1, 3 & 4

7.2. Manufacturer's Responsibilities During Testing Process

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).
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.
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.

7.3. 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, according to Table 2. Response to step changes in temperature will be measured. An arbitrary pair of groups shall be retested with simultaneous steam actuation.

7.4. 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, according to Table 2. Pressure readings during the first three seconds of the cycle shall be ignored, to account for pressure gauge lag.

7.5. Extraction Testing

7.5.1 Coffee

Coffee used for extraction testing shall be entirely comprised of arabica, with a roast level of 55-65 (Agtron "Gourmet" scale).

7.5.2 Testing Procedure

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%. For this series of extractions, a maximum amount of 20 g of coffee shall be used, though the weight of brewed espresso may vary to cover the range of brewing ratios. 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.

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 puck. The location of the temperature probe shall be off center, approximately one-third 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, with accuracy of ±0.05% of reading or ±0.3°C, 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 puck shall be replaced by a proxy puck. 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 data logger. An example of the intended measurement system is depicted in Figures 1-3. This system is termed "Scace device."

Figure 1: Portafilter thermometer top view, showing the type T thermocouple probe and the puck 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

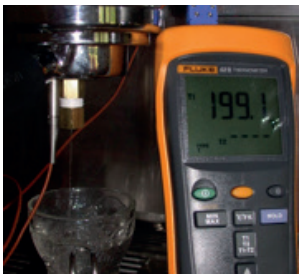

Figure 3: Installed portafilter thermometer measuring the temperature of the metered brew water stream

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" or "naked" portafilter).

A.2.3 Simulation of the Puck

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

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 puck 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 screens are removable for servicing, then they 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 one (1) hour 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 (using a scale with 0.1 g nominal accuracy) is collected in an elapsed time of 25±3 seconds.

A.3.4 Steaming Performance

Brew water testing includes testing of steam performance, the elapsed time required to steam 300 cm^3 of milk (initially at 3 to 5°C) 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 purpose 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. (Table 3)

B. Simulated disposal of coffee puck, dosing, and tamping: The portafilter shall be removed from the machine, drained of excess water (inversion is sufficient), then reinserted into the group 25 seconds 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 two (2) seconds.

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 seconds.

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 as specified in Table 3.

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

Table 3 Length of the idle interval during temperature testing

A.4.3 Number of Groups to be Tested

Individual or multiple groups may be tested. Multiple groups should be tested in combinations as per Table 2 and in any portafilter insertion order, including nominally simultaneous insertion.

A.4.4 Test Procedure Including Effects of Steaming Milk

The test procedure shall be performed with the inclusion of simulated steaming. If this is desired, then the steam valve shall be opened in Step A.4.1. (D) 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 may 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 3 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 shall also be tested including simulated steaming as 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) shall 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 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 and reported graphically.

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