



Method for Measuring Performance of Portable Household Electric Room Air Cleaners

ANSI/AHAM AC-1-2015



PREFACE

The Association of Home Appliance Manufacturers (AHAM) develops standards in accordance with AHAM's "Policy and Procedures Governing Technical Standards" which states:

"AHAM Standards shall be in the best interest, mutually, of consumers who use appliances, the industries which provide and service appliances, and other interested parties. They shall relate to actual use conditions, be technically and scientifically sound."

Use or observance of AHAM standards is voluntary.

AHAM standards are presented to the American National Standards Institute (ANSI) for recognition as American National Standards. This standard was so recognized on May 13, 2015 and bears the American National Standard designation ANSI/AHAM AC-1-2015.

This standard contains test procedures which may be applied to any brand or model of portable household electric room air cleaners within the stated confines of the standard's limits of measurability for measuring performance. Results of tests in accordance with this standard may be publicly stated.

With regard to safety, AHAM recommends that all appliance products - both major and portable appliances - manufactured or marketed in the United States be submitted to an appropriate independent Nationally Recognized Testing Laboratory for inspection and listing in conformance with the safety standards and procedures followed by such laboratories. The relevant standards for portable household electric room air cleaners are UL 867, "Standard for Electrostatic Air Cleaners" and UL 507, "Standard for Fans."

The annexes to this standard are included for informational purposes only unless the annexes are noted as normative.

AHAM welcomes comments and suggestions regarding this standard. Any standard may be reviewed and improved as needed. All standards must be updated or reconfirmed at least every five years. Any interested party, at any time, may request a change in an AHAM standard. Such request should be addressed to AHAM's President, and should be accompanied by a statement of reason for the request and a suggested alternate proposal.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

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1. PURPOSE

This standard method establishes uniform, repeatable procedures and standard methods for measuring specified product characteristics of portable household electric room air cleaners.

The standard methods provide a means to compare and evaluate different brands of portable household electric room air cleaners regarding characteristics significant to product use.

The standard methods of measurement are not intended to inhibit improvement and innovation in product testing, design or performance.

2. SCOPE

This standard method applies to portable household electric room air cleaners as defined in Section 3.

This standard method includes definitions and safety characteristics of portable household electric room air cleaners of the types indicated.

This standard method measures the relative reduction by the air cleaner of particulate matter suspended in the air in a specified test chamber. It also prescribes a method for measuring the operating power and standby power of the air cleaner.

This standard method has defined limits of measurability based on the statistical accuracy of the methods. Based on a 95% confidence limit (2 standard deviations), a CADR cannot be distinguished between zero (0) and a CADR rating less than those CADR limits shown below. Therefore, the standard only applies to air cleaners with minimum CADR ratings of:

Dust	CADR = 10 cfm
Cigarette smoke	CADR = 10 cfm
Pollen	CADR = 25 cfm

The maximum CADR values are determined based on theoretical maximum limits. The theoretical maximum limits are determined by the maximum number of initial available particles, the acceptable minimum number of available particles, an average background natural decay rate (from statistical study), the size of the test chamber, and the available minimum experiment time. CADR values for dust and cigarette smoke greater than those listed will not have the necessary statistical data required by this method. CADR values for pollen greater than those listed will not have the necessary statistical data required by this method. CADR values for pollen approaching that listed are normally determined by pooling of the test value data determined under this method. Therefore, the standard only applies to air cleaners with maximum CADR ratings of:

Dust	CADR = 400 cfm
Cigarette smoke	CADR = 450 cfm
Pollen	CADR = 450 cfm

The precision of the Standard as based on a 0 CADR air cleaner expressed as 2 standard deviation limits (95%) are:

Dust	CADR = ± 10 cfm
Cigarette Smoke	CADR = ± 10 cfm
Pollen	CADR = ± 25 cfm

3. DEFINITIONS

3.1 Portable Household Electric Room Air Cleaner (“Air Cleaner”)

An electric appliance with the function of removing particulate matter from the air and which can be moved from room to room. Herein referred to as “air cleaner.”

3.1.1 Air Cleaner - Floor Type

Floor type air cleaners are designed to stand alone on the floor of a room and are designated as stand-alone floor models by the manufacturer. Appliances of this type are tested on the floor facing the test window as close to the center of the test chamber as possible.

3.1.2 Air Cleaner - Table Type

Table type air cleaners are designed to set on a table or counter by the manufacturer. Appliances of this type are tested on the table stand facing the test window at the center of the test chamber.

3.1.3 Air Cleaner - Wall Type

Wall type air cleaners are designed either to attach to a wall and are designated as wall mountable by the manufacturer or as a plug-in air cleaner. A wall type air cleaner must include appropriate wall mounting brackets or specifically designated instructions to mount the air cleaner integrally to the wall (i.e. not a shelf). Appliances of this type are tested on the wall mount stand facing the test window placed at the center of the test chamber (refer to Annex G).

3.1.4 Air Cleaner - Combination Type

Combination type air cleaners are designed to operate in one or more orientations/positions (floor, table, wall) as designed by the manufacturer. A combination type air cleaner may be tested at the center of the test chamber facing the test window on the floor, table, or wall mount stand, according to how it has been designated by the manufacturer (See 3.1.1, 3.1.2 and 3.1.3).

3.1.5 Air Cleaner - Ceiling Type

Air cleaner appliances designed to be mounted on the ceiling are considered outside the scope of this method as defined in Section 3. Uniform testing practices and statistical examination of such appliances have not been conducted.

3.1.6 Air Cleaner - Plug-In Type

A fixed location air cleaner directly connected to an electric receptacle (outlet) by means of direct plug-in (no electric cord). Appliances of this type are tested at the lower level electrical receptacle of the plug-in type test stand facing the test window as shown in Annex G.

3.2 Design Characteristics of Portable Household Electric Room Air Cleaners

3.2.1 Fan with Filter

Air cleaners that operate with an electrical source of power and which contain a motor and fan for drawing air through a filter media.

3.2.2 Fan and Electrostatic Plates

Air cleaners that operate with a fan and incorporate electrically charged plates or wires to electrostatically collect particulate matter. Such devices may include a filter(s).

3.2.3 Fan Filter with Ion Generator

Air cleaners that incorporate an ion generator in addition to a fan and filter.

3.2.4 Ion Generator

Air cleaners that incorporate an ion generator only.

3.2.5 Hybrid

Any air cleaner employing a combination of the above definitions of fan with filter, electrostatic plate/wire, and ion generator.

3.2.6 Other Types

A device that has the stated capability to reduce the concentration of particulate matter in a room. Such devices do not have to contain a fan and can incorporate any of the particle removal methods noted above.

3.3 Test Particulate Matter

3.3.1 Cigarette Smoke

Smoke produced by burning cigarette tobacco with air forced through the cigarette's filter having particle sizes detected from 0.10 µm to 1.0 µm diameter.

3.3.2 Air Cleaner Fine Fraction Test Dust

Commercially available test dust with particle sizes detected from 0.5 µm to 3.0 µm.

3.3.3 Pollen

Particulate matter naturally occurring from plants. The pollen to be used is Paper Mulberry Pollen (non-defatted) with a particle size range of 5 µm to 11 µm, including fragments.

3.4 Test Chamber

The room size chamber for determining performance in removing particulate matter from the air. (The specifications for the AHAM chamber are in Annex A.)

3.5 Air Circulating Equipment

3.5.1 Ceiling mixing fan

A high volume ceiling fan used to mix the test chamber during contaminant aerosol generation.

3.5.2 Recirculation Fan

A fan capable of producing between 300 and 400 cfm and used for the purpose of maintaining a homogeneous environment within the test chamber (as specified in Annex A).

3.6 Particulate Matter Removal

The reduction of particle number concentration in air due to the operation of the air cleaner.

3.7 High Efficiency Particulate Air (HEPA) Filter

An air filter with greater than or equal to 99.97% removal of dioctyl phthalate at 0.3 μm diameter. NOTE: The fractional efficiency of such filters can be verified using Mil-Std-282 or IEST-RP-CC007.1

3.8 Aerosol Generator

A device that produces and disseminates liquid or solid particles that are suspended in air.

3.8.1 Cigarette Smoke Generator

An aerosol generator that disseminates test cigarette smoke with particle sizes specified in Section 3.3.1 into the air.

3.8.2 Dust Generator

An aerosol generator that disseminates test dust with particle sizes specified in Section 3.3.2 into the air.

3.8.3 Pollen Generator

An aerosol generator that disseminates test pollen with particle sizes specified in Section 3.3.3 into the air.

3.9 Cigarette Humidity Chamber

A chamber able to maintain a temperature of $39^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$ ($4^{\circ}\text{C} \pm 2^{\circ}\text{C}$) and relative humidity of $(50 \pm 10) \%$, for the long-term storage of test cigarettes

3.10 Particle Number Concentration

Number of particles per cubic centimeter of room air.

3.10.1 Initial Concentration

The particulate concentration at the start of test time ($t=2$ for smoke test, $t=0$ for dust or pollen test).

3.10.2 Background Concentration

The particulate concentration in the test chamber before the particulate is introduced to the chamber.

3.11 Aerosol Spectrometer

Device for measuring particle size distribution in room air (See Annex A).

3.12 Cigarette Smoke Diluter

Device for reducing the concentration of cigarette smoke by a known factor to a concentration suitable for instrument measurement.

3.13 Natural Decay

The reduction of particulate matter due to natural phenomena in the test chamber: principally agglomeration, surface deposition (including sedimentation), and air exchange.

3.14 Clean Air Delivery Rate (CADR)

The measure of air cleaner performance by this test procedure Clean Air Delivery Rate (CADR) is defined as the measure of the delivery of contaminant free air, within the defined particle size range, by an air cleaner, expressed in cubic feet per minute (cfm). Clean Air Delivery Rates are the rates of contaminant reduction in the test chamber when the air cleaner is turned on, minus the rate of natural decay when the air cleaner is not running, multiplied by the volume of the test chamber as measured in cubic feet (See Section 8.5). CADRs values are always the measurement of an air cleaner performance as a complete system, and they have no linear relationship to air movement per se or to the characteristics of any particular particle removal methodology.

3.15 Room Size

Maximum suggested room size for an air cleaner. The room size is determined by mathematical modeling of steady state and is based on the CADR requirement to remove 80% of cigarette smoke particles between 0.1 and 1.0 microns on a steady-state (continuous) basis. See 8.6 and Annex E.

4. GENERAL CONDITIONS FOR MEASUREMENT

Conduct measurements under the following conditions:

4.1 Electrical Supply

Standard frequency and voltage for the CADR testing and operating power test are listed under 4.1.1 and 4.1.2. Other frequencies and voltages may be used to produce CADR values. The specific electrical supply conditions shall be concurrently reported with the applicable CADR values.

NOTE: Refer to Section 9 for the Measurement of Operating Power Test.

4.1.1 Frequency

(60±1) Hertz

4.1.2 Voltage

Operate air cleaner at (115 ± 1) Volts.

NOTE: Refer to Section 10 for the Voltage requirements for the Measurement of Standby Power Test.

4.2 Test Chamber Ambient Temperature

Test Chamber ambient temperature is to be (21 ± 3)°C [(70 ± 5)°F] with a relative humidity (RH) of (40 ± 5)% for CADR and the Measurement of Operating Power tests.

NOTE: Refer to Section 10 for the Temperature requirements for the Measurement of Standby Power Test.

4.3 Test Chamber Air Exchange Rate

The test chamber air exchange rate is to be less than 0.03 air changes per hour (ACH) as determined by ASTM E 741 (*Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution*) or an equivalent method.

4.4 Test Chamber Particulate Concentrations

4.4.1 Measurability

The acceptable range of particle concentrations for the initial test condition (time (t) = 2 minutes for cigarette smoke, t = 0 minutes for dust or pollen) are:

(See Appendix H)

Cigarette Smoke: 24,000 to 35,000 particles/cc (diluter may be required)

Sampling period, (20 sec. @ 0.06 liter/min ± 5 %)

Dust: 200 to 400 particles/cc

Sampling period, (20 sec. @ 1 liter/min ± 5 %)

Pollen: 4 to 9 particles/cc

Sampling period, (20 sec. @ 1 liter/min ± 5 %)

NOTE: Use of a particle counter with different flow rates than the ones specified above is acceptable as long as the particle counter provides equivalent performance characteristics.

The lower limit of instrument measurability is based on a minimum of 10 particle counts and is defined by the practical counting limits of particle measuring instrumentation. These are:

Dust	0.03 particles/cc
Cigarette smoke	20 particles/cc
Pollen	0.03 particles/cc

4.4.2 Test Chamber Background Concentration

The allowable concentration of particulate matter in the test chamber prior to the introduction of the test particulate. This concentration is not to be greater than the lower limit of instrument measurability. (If the instrument's measurability lower limit cannot readily be achieved, further test chamber cleaning procedures shall be performed.)

4.5 Chamber Equipment

The recirculation fan is to be operated throughout all tests in Sections 5, 6, and 7. See Annex A for proper positioning of the recirculation fan.

4.6 Test Equipment Preparation

4.6.1 Check contaminant generating, measuring and recording instruments, and data processing equipment for readiness per manufacturer's instructions (See Annex C).

4.6.2 Air cleaner is installed per manufacturer's instructions, placing the air cleaner (or test fixture containing the air cleaner) in the center of the test chamber, facing the test window, positioned with its air discharge as close as possible to the test chamber center. For air cleaners that discharge air in a specific direction, the air discharge shall not be pointed toward the particle monitors. If manufacturer's instructions do not specify (and air cleaner is not a floor model), place the air cleaner on the table for test. [Refer to Section 3.1 for positioning of specify types of air cleaners in the test chamber.] Air cleaners with multi-level performance fan settings are typically adjusted to the highest air cleaning mode setting for test. Other performance settings shall be concurrently reported with the applicable CADR values (See Annex C).

5. TEST PROCEDURE FOR DETERMINING PERFORMANCE ON CIGARETTE SMOKE.

To determine the performance on cigarette smoke, perform the test procedures prescribed in Sections 5.1 and 5.2 sequentially during the same test period (Annex C, III.A). An appropriate cigarette smoke sample diluter (see Annex A) is to be used with the cigarette smoke monitor.

5.1 Natural Decay Measurement

- 5.1.1 Place the air cleaner to be tested in the test chamber in accordance with Section 4.6.2 and set the air cleaner controls to the conditions for test. Test for proper operation, then shut off with switch external to test chamber.
- 5.1.2 Operate the ceiling mixing fan and create a log file for the run.
- 5.1.3 Using the test chamber HEPA filter, allow the test chamber air to clean until the background concentration in the size range of 0.1 μm to 1.0 μm reaches a concentration of less than 20 particles/cc. Simultaneously operate the environmental control devices until the test chamber conditions (temperature and RH) are as specified in Section 4.2.
- 5.1.4 Procedure
 - 5.1.4.1 When an acceptable test chamber background concentration (particle number concentration) is achieved (as indicated in Section 5.1.3) record the background concentration, turn off the test chamber environmental control system (humidifiers, HEPA filter, blowers, supply dampers, and return dampers.)
 - 5.1.4.2 Immediately light, then place one standard cigarette obtained from the cigarette humidity chamber in the cigarette smoke generator, seal generator, open valve to test chamber, and turn on 4-6 scfh air supply to the cigarette generator to provide the required initial concentration (24,000 to 35,000 particles/cc as noted in Section 4.4.1).

NOTE: It should take approximately 45 seconds to reach the required initial concentration.
 - 5.1.4.3 Turn off air supply and close test chamber valve.
 - 5.1.4.4 Mix cigarette smoke for one minute after the initial concentration has been reached, then turn off ceiling mixing fan. The recirculation fan will continue to operate for the duration of the test.
- 5.1.5 Three minutes after turning off ceiling mixing fan, begin to acquire the cigarette smoke particulate concentration. This test point is the initial concentration ($t=2$ minutes). If the cigarette smoke concentration is not within the initial limits (refer to Section 4.4.1), terminate the run.
- 5.1.6 Acquire particle concentration data at one-minute intervals 20 minutes. A minimum of nine data points having particle concentrations greater than the lower limit of instrument measurability are required.
- 5.1.7 Record the average RH and temperature of the test chamber during the test period. Values outside the limits in Sections 4.2 and 4.3 invalidate the run.
- 5.1.8 Calculate the decay constant for cigarette smoke per Section 8.2

- 5.1.9 Determine the acceptability of the run by calculating the standard deviation of the natural decay in accordance with Section 8.3. A standard deviation of less than the 95% confidence limit of 0.002 min^{-1} or 10%, whichever is greater, determines the acceptability of the run.

5.2 Cigarette Smoke Particulate Matter Removal Measurement with Air Cleaner Operating (includes natural decay)

- 5.2.1 Operate the ceiling mixing fan and create a log file for the run.
- 5.2.2 Using the test chamber HEPA filter, allow the test chamber air to clean until the background concentration in size range of $0.1 \mu\text{m}$ to $1.0 \mu\text{m}$ reaches a concentration of less than 20 particles/cc and simultaneously operate the environmental control devices until the test chamber conditions (temperature and RH) are as specified in Section 4.2.
- 5.2.3 Procedure
- 5.2.3.1 When an acceptable test chamber background concentration is achieved (as indicated in Section 5.2.2), record the background concentration, turn off the test chamber environmental control system (humidifiers, HEPA filter, blowers, supply dampers and return dampers.)
- 5.2.3.2 Immediately light, then place one standard cigarette obtained from the cigarette humidity chamber in the cigarette smoke generator, seal generator, open valve to test chamber, and turn on 4-6 scfh (about 45 sec.) air supply to the cigarette generator to provide the required concentration (as noted in Section 4.4.1).
- 5.2.3.3 Turn off air supply and close chamber valve. Mix cigarette smoke for one minute, then turn off ceiling mixing fan. The recirculation fan will continue to operate for the duration of the test. Wait one minute for fan to stop. Turn on air cleaner. The time at which the air cleaner is turned on is defined as time (t) = 2 minutes.
- 5.2.4 Two minutes after turning on the air cleaner, begin to acquire the cigarette smoke particulate concentration. This test point is the initial concentration. If the cigarette smoke concentration is not within the initial limits (refer to Section 4.4.1), terminate the run.
- 5.2.5 Acquire particle concentration data at one-minute intervals for 20 minutes, beginning at the two minute point (t=2 minutes). Use all acceptable data points. Refer to Section 8.1 for Elimination of Data Points to determine acceptability. A minimum of nine acceptable data points are required.
- NOTE: The operating power test described in Section 9 can be conducted during this particle concentration data acquisition phase if desired.
- 5.2.6 Turn off the air cleaner. Record the average RH and temperature of the test chamber during the test period. Values outside the limits in Sections 4.2 and 4.3 invalidate the run.
- 5.2.7 Calculate the decay constant for cigarette smoke per Section 8.2.
- 5.2.8 Determine the acceptability of the run by calculating the standard deviation of the particulate matter removal in accordance with Section 8.3. A

standard deviation of less than the 95% confidence limit of 0.008 min^{-1} or 10%, whichever is greater, determines the acceptability of the run.

5.2.9 Determine the CADR of the air cleaner in accordance with Section 8.4.

5.2.10 Determine the acceptability of the test by calculating an estimate of the standard deviation for a single test CADR according to Section 8.5. A two standard deviation estimate of less than CADR of 9 cfm or 10%, whichever is greater, determine an acceptable test.



6. TEST PROCEDURE FOR DETERMINING PERFORMANCE ON TEST DUST

To determine the performance on test dust, perform the test procedures prescribed in Sections 6.1 and 6.2 sequentially during the same day (Annex C, III.B.)

6.1. Natural Decay Measurement

- 6.1.1 Place the air cleaner to be tested in the test chamber in accordance with Section 4.6.2 and set the air cleaner controls to the conditions for test. Test for proper operation, then shut off with switch external to test chamber.
- 6.1.2 Operate the ceiling mixing fan and create a log file for the run.
- 6.1.3 Using the test chamber HEPA filter, allow the test chamber air to clean until the background concentration in the size range of $0.5\ \mu\text{m}$ to $3.0\ \mu\text{m}$ reaches a level of less than 0.03 particle/cc. Simultaneously operate environmental control devices until the test chamber conditions (temperature and RH) are as specified in Section 4.2.
- 6.1.4 Procedure
 - 6.1.4.1 When an acceptable test chamber background concentration is achieved (as indicated in 6.1.3) record the background concentration. Turn off the test chamber environmental control system (humidifiers, HEPA filter, blowers, supply dampers and return dampers.)
 - 6.1.4.2 Immediately turn on the air supply to the aerosol generator and then the aerosol generator. Continue to generate test dust until the particle concentration in the test chamber reaches the required initial concentration (200 to 400 particles/cc as noted in Section 4.4.1).
 - 6.1.4.3 When the concentration is within initial test limits, turn off the aerosol generator air supply and aerosol generator. CAUTION: A radioactive source is utilized by the dust generator for charge neutralization.
 - 6.1.4.4 Mix dust for one minute after the initial concentration has been reached, then turn off ceiling mixing fan. Wait one minute for the fan to stop. The recirculation fan will continue to operate for the duration of the test.
 - 6.1.4.5 Begin to acquire the particle concentration with the dust monitor. This test point is the initial concentration ($t=0$ minutes). If the test dust concentration is not within initial limits, terminate the run.
- 6.1.5 Acquire particle concentration data at one-minute intervals for 20 minutes. A minimum of nine data points having particle concentrations greater than the lower limit of instrument measurability are required.
- 6.1.6 Record the average RH and temperature of the test chamber during the test period.
- 6.1.7 Calculate the decay constant for test dust per Section 8.2
- 6.1.8 Determine the acceptability of the run by calculating the standard deviation of the natural decay in accordance with Sections 8.3. A standard deviation of less than the 95% confidence limit of $0.001\ \text{min}^{-1}$ or 10%, whichever is greater, determines the acceptability of the run.

6.2. Dust Particulate Matter Removal Measurement with Air Cleaner Operating (includes natural decay).

- 6.2.1 Operate the ceiling mixing fan and create a log file for the run.
- 6.2.2 Using the test chamber HEPA filter, allow the test chamber air to clean until the background concentration in the size range of $0.5\ \mu\text{m}$ to $3.0\ \mu\text{m}$ reaches a concentration of less than 0.03 particle/cc. Simultaneously operate the environmental control devices until the test chamber conditions (temperature and RH) are as specified in Section 4.2.
- 6.2.3 Procedure
 - 6.2.3.1 When an acceptable test chamber background concentration is achieved (as indicated in 6.2.2), record the background concentration, turn off the test chamber environmental control system (humidifiers, HEPA filter, blowers, supply dampers and return dampers.)
 - 6.2.3.2 Immediately turn on the air supply to the aerosol generator and then the aerosol generator. Continue to generate test dust until the particle concentration in the test chamber reaches the required initial concentration (200 to 400 particles/cc as noted in Section 4.4.1).
 - 6.2.3.3 When the concentration is within initial test limits, turn off the aerosol generator air supply and aerosol generator. CAUTION: A radioactive source is utilized by the dust generator for neutralization.
 - 6.2.3.4 Mix dust for one minute, then turn off ceiling mixing fan. Wait one minute for fan to stop. Turn on air cleaner. This is $t=0$ minutes.
- 6.2.4 Begin to acquire the particle concentration with the dust monitor at $t=0$ minutes. This test point is the initial concentration. If the test dust concentration is not within the initial limits, terminate the run.
- 6.2.5 Acquire particle concentration data at one-minute intervals for 20 minutes, beginning at $t = 0$ minutes. Use all acceptable data points. Refer to Section 8.1, Criteria for Elimination of Data Points to determine acceptability. A minimum of nine acceptable data points are required.

NOTE: The operating power test described in Section 9 can be conducted during this particle concentration data acquisition phase if desired.
- 6.2.6 Turn off the air cleaner. Record the average RH and temperature of the test chamber during the test period. Values outside the limits in Sections 4.2 and 4.3 invalidate the run
- 6.2.7 Calculate the decay constant for test dust per Section 8.2
- 6.2.8 Determine the acceptability of the run by calculating the standard deviation of the particulate matter removal in accordance with Sections 8.3. A standard deviation of less than the 95% confidence limit of $0.003\ \text{min}^{-1}$ or 10%, whichever is greater, determines the acceptability of the run.
- 6.2.9 Determine the CADR of the air cleaner in accordance with Section 8.4.
- 6.2.10 Determine the acceptability of the test by calculating an estimate of the standard deviation for a single test CADR according to Section 8.5. A two