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Superseding J335 SEP90

Submitted for recognition as an American National Standard

(R) MULTIPOSITION SMALL ENGINE EXHAUST SYSTEM FIRE IGNITION SUPPRESSION

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. **Scope**—This SAE Recommended Practice establishes equipment and test procedures for determining the performance of spark arrester exhaust systems of multiposition engines used in hand-held portable applications. It is not applicable to spark arresters used in vehicles or stationary equipment.

1.1 **Purpose**—This document provides a method of testing to evaluate the fire ignition potential of exhaust systems of small multiposition portable engines.

1.2 **Performance**—Recommended performance criteria are given in Appendix A which are adequate for the severe fire hazard condition posed by heavy vegetative fuels. However, during periods of extreme fire danger, exhaust systems meeting this document may not give absolute protection against fires. Additional control of operations may be necessary during such periods.

2. **References**

2.1 **Applicable Publications**—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J997—Spark Arrester Test Carbon

SAE J1349—Engine Power Test Code—Spark Ignition and Diesel

2.1.2 USDA FOREST SERVICE PUBLICATIONS—Available from USDA Forest Service Technology and Development Center, 444 East Bonita Avenue, San Dimas, CA 91773-3198.

D.S. Stocksted, "Spontaneous and Piloted Ignition of Pine Needles," Research Note INT 194, USDA Forest Service, Northern Forest Fire Laboratory (1975)

D.S. Stocksted, "Spontaneous and Piloted Ignition of Cheatgrass," Prepublication Research Note, USDA Forest Service, Northern Forest Fire Laboratory (1976)

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R.T. Harrison, "Danger of Ignition of Ground Cover Fuels by Vehicle Exhaust Systems," ED & T Report 5100-15, USDA Forest Service, San Dimas Equipment Development Center (1970)

Anon, "Standard Test Procedure for General Purpose Spark Arresters," USDA Forest Service, San Dimas Equipment Development

3. Definitions

- 3.1 Multiposition Small Engine (MSE)**—A hand-held power unit having an internal combustion engine operable in more than one position. MSE configurations include chain saws, weed trimmers, brush cutters, blowers, hedge trimmers, and cutoff saws.
- 3.2 Power Unit**—A MSE unit exclusive of removable extensions such as chain saw bar and chain, brush cutter and trimmer shaft assemblies, hedge trimmer blade, cutoff saw blade extension, blower ducts, etc.
- 3.3 Spark Arrester**—An exhaust system having the ability to control the amount and size of particulate carbon or metal particles emitted into the atmosphere. An exhaust grill or guard is a component of the spark arrester exhaust system, if when removed, the test engine can still be operated.
- 3.4 Contact Plane**—An imaginary flat surface defined by at least three points of contact on the surface of MSE power unit extremities.
- 3.5 Exposed Surfaces Temperature Test**—A test which measures exhaust system temperatures at the points where the engine exhaust system comes in contact with or intersects the contact plane surfaces established by the extremities of the MSE.
- 3.6 Exhaust Gas Temperature Test**—A test which measures exhaust gas temperature at the points where the hottest gases impinge a contact plane.
- 3.7 Shall**—Indicate a mandatory requirement exclusive of all other methods.
- 3.8 Should**—An advisory condition.
- 3.9 May**—A permissive condition.
- 3.10 Best Power**—Power at maximum torque achievable by a given test MSE at the maximum continuous corrected net brake power speed. (See SAE J1349.)

4. Instrumentation—The following instrumentation is required:

- 4.1 Calibrated Loading Device**—An apparatus designed to test MSEs at given loads and speeds which display torque or power and is compatible with a multipoint recorder or data logger. A calibrated loading device is required in chain saw temperature testing and is optional in temperature testing of MSEs other than chain saws.
- 4.2 Tachometer**—A device for determining the rotational speed of a MSE. It may be separate or integrated with the calibrated loading device or multipoint recorder or data logging device.
- 4.3 Exhaust Gas and Surface Temperature Thermocouples**—Temperature thermocouple composed of Standard J or K type thermocouple wire with a grounded junction and a probe sheath diameter of 3.2 mm (1/8 in) or smaller.

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4.4 Graduated Cylinders—Calibrated containers for measuring amounts of fuel and lubricant for the fuel mix with an accuracy of $\pm 2\%$ of the amount actually contained.

4.5 Wire Plug Gage—A round wire gage of 0.610 mm (0.024 in) diameter with precision ground squared ends. Replace if any rounding is noted.

5. Screen Test—When gaging, do not exceed 2 oz (1.73×10^{-2} N) of force.

The following screen test shall be made on all MSE screen-type spark arresters:

5.1 Screen Housing Seal—With the screen installed, probe the entire periphery for any gaps in the mounting structure. Any penetration using the wire plug test gage fails the test.

5.2 Test With Screen Removed—Remove the screen from the exhaust system and randomly probe the screen at least 20 times. Especially pay attention to any bends, molding, or edges. Any penetration using the wire plug gage fails the test.

5.3 Screen Housing Seal After Reassembly—Install the screen in the exhaust system and repeat 5.1.

6. Contact Plane Determination—The contact planes are determined by the following method:

6.1 General

6.1.1 Determine the configuration of the MSE to be tested in accordance with 6.2 through 6.7.

6.1.2 Slowly roll the test plate around the MSE exhaust system, or roll the MSE around the exhaust system on a flat surface, examining the gas exhaust stream outlet area. For each plane checked, mark at least three contact points or a point and line contact, to form a flat plane. (Refer to Figures 1 and 2.) When locating contact points, document the areas where the test plane touches the muffler assembly. Mark the contact points.

6.1.3 Use 3.2 mm (1/8 in) to 6.4 mm (1/4 in) pin stripe drafting tape or use a stiff, straight, 3.2 mm (1/8 in) thick hard wire or welding rod to connect the 3 or more contact points. These types of plane indicators may be fixed to the test unit for more accurate thermocouple probe alignment during the test.

If a wire form is used, the inner radius of the metal rods must exactly describe the contact plane without moving inside or away from the contact plane. The point of contact must be clearly visible and the inner radius of the metal rods flush with the contact points. The diameter of the metal rods must not be overlapping and the metal rods must be straight.

6.2 Chain Saws

6.2.1 Assemble per manufacturer's specification, less bar and chain, fuel, and oil.

6.2.1.1 If spikes or bumper bars are supplied and required by the manufacturer, test the saw with spikes in place. Locate the test planes from the roots of the bumper spikes.

6.2.2 Fit a spacer, the same thickness as the bar, between the clutch cover and body and reinstall the bolts. The spacer shall not protrude beyond the body of the saw.

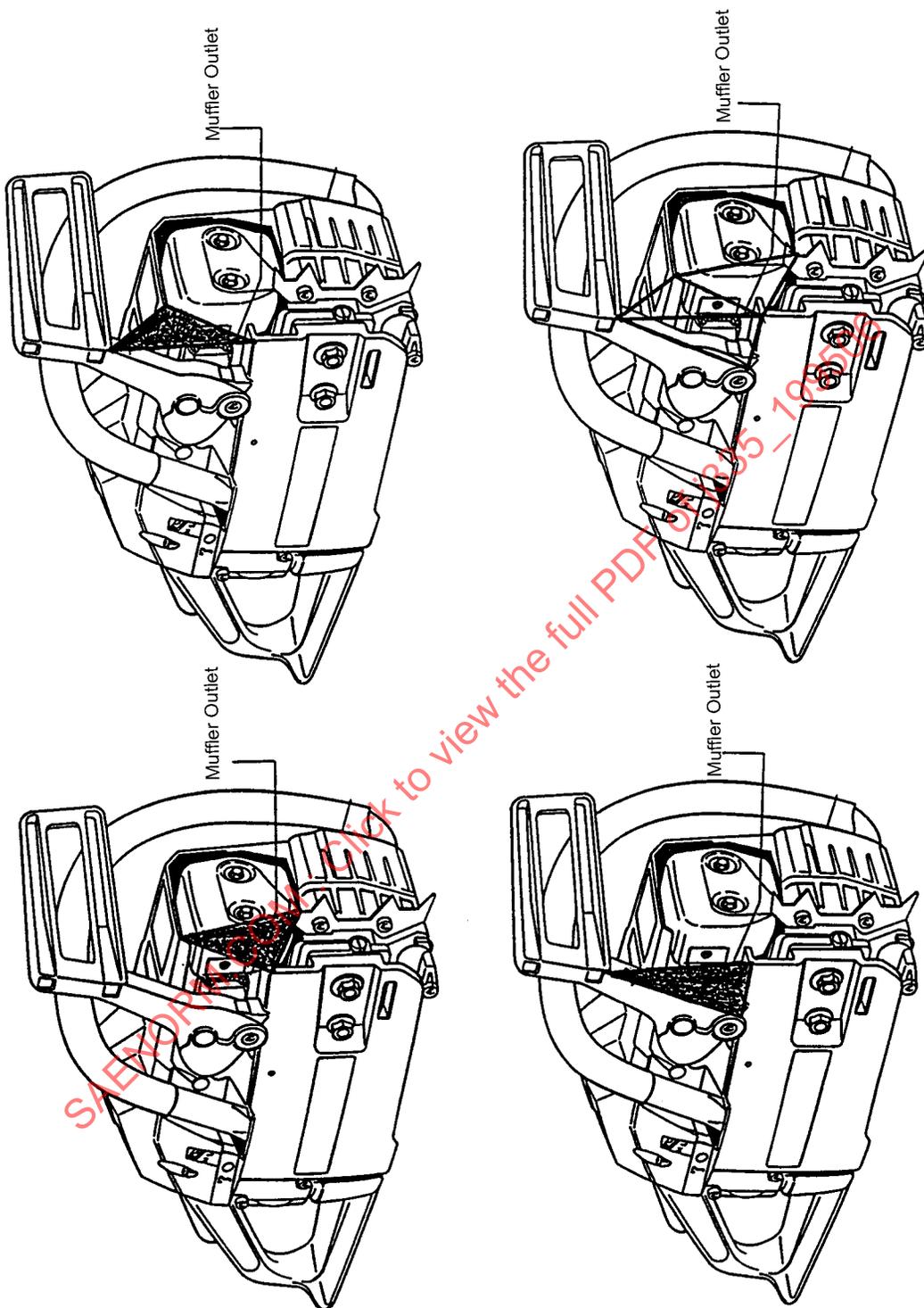


FIGURE 1—CHAIN SAW WITH CONTACT PLANES IDENTIFIED

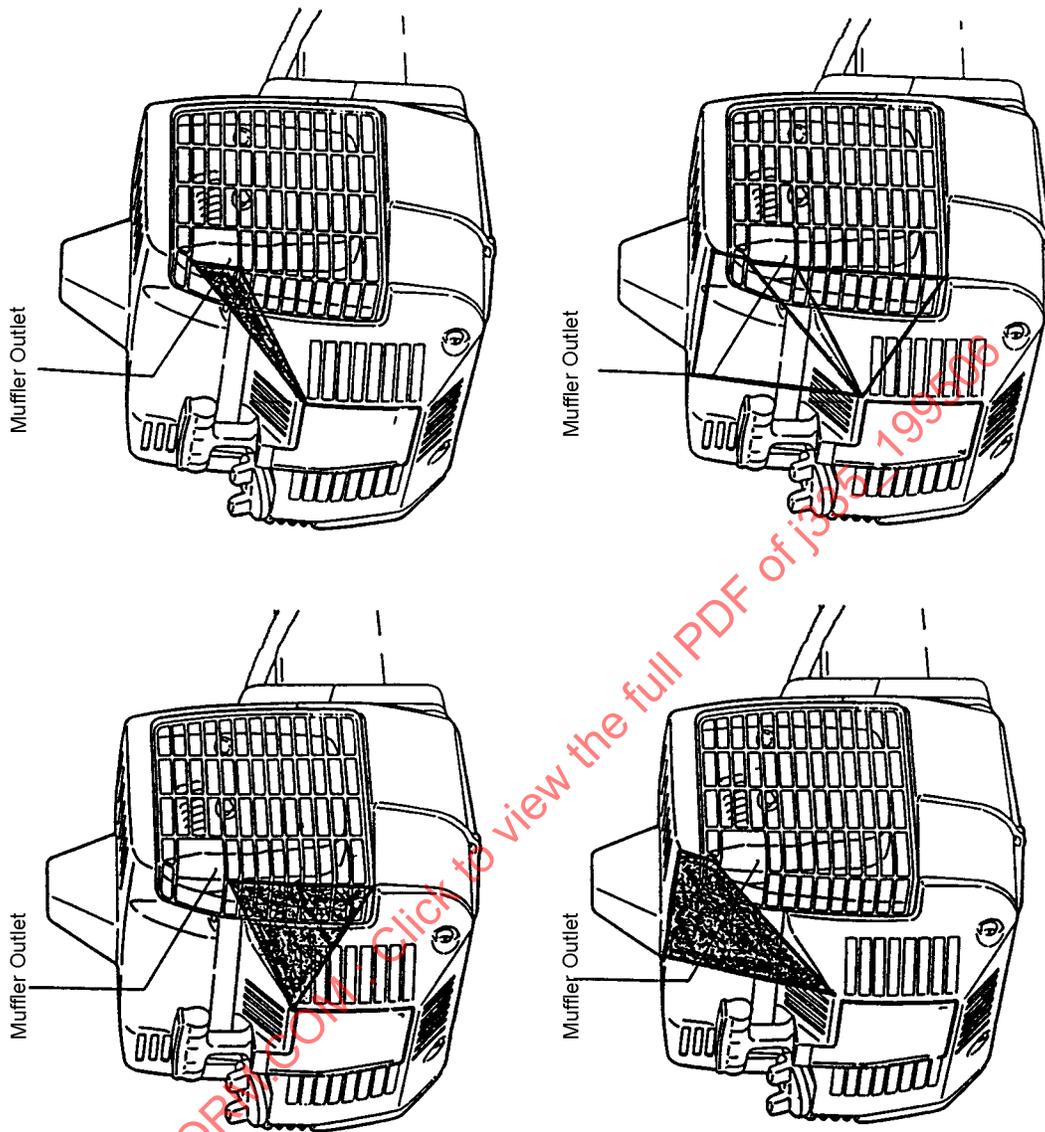


FIGURE 2—BRUSH CUTTER WITH CONTACT PLANES IDENTIFIED

- 6.2.3 Place the chain brake in the "OFF" or disengaged position and deflect the hand guard by the weight of the saw into its most rearward position. Use tape to secure the chain brake and hand guard in this position.
- 6.2.4 Determine the planes per 6.1.
- 6.3 String Trimmers and Brush Cutters**—Use the power head and lower end shaft to determine the planes per 6.1.
- 6.4 Blower**—Use 6.1 with an exception: Where the exhaust port is vented within the blower duct, thermocouples should be attached to the outlet surface of the exhaust outlet duct. Thermocouples should be attached to the outlet surface of the exhaust outlet.

- 6.5 Hedge Trimmers**—Excluding the cutter bar, use bar mount to determine planes per 6.1.
- 6.6 Cutoff Saws**—Remove blade and rotate blade housing. Establish contact plane as the closest possible plane to the muffler and exhaust outlet.
- 6.7 Other MSE Configurations**—Determine planes for other configurations (that is, power drills, impact devices, and compactors) without attachments or detachable accessories.
- 7. Temperature Test**—Perform the following temperature tests on all MSEs:
- 7.1 Exposed Surfaces Temperature Test**—Measure exhaust system temperatures at the points where the engine exhaust system comes in contact with the plane surfaces established per 6.1.
- 7.1.1 TEST APPARATUS—Use thermocouples welded or brazed to the exhaust system to determine temperatures. For chain saws, a calibrated loading device is required (Section 8).
- NOTE—During all tests, a thermocouple should be mounted to the cylinder head or spark plug gasket to monitor the head temperature.
- 7.2 Exhaust Gas Temperature Test**—Measure exhaust gas temperature at the points where the hottest gases impinge a plane established per 6.1.
- 7.2.1 TEST APPARATUS—Use thermocouples to measure the exhaust gas temperature. For chain saws, a calibrated loading device is required.
- NOTE—During all tests, a thermocouple should be mounted to cylinder head or spark plug gasket to monitor head temperature.
- 7.3 Test Data**—The test data to be recorded for MSE temperature testing shall include the time, exhaust gas temperature, head and ambient temperatures, engine speed, torque and the exhaust surface temperature, if required. Recorded test data for MSEs other than chain saws may omit the torque data, if a calibrated loading device was not used. Recorded test data for MSEs other than chain saws shall include the method of loading, including the approximate percentage of the exhaust port area blocked for blowers.
- 8. Detailed Temperature Test Methods**—Use the following temperature test methods to test MSE exhaust systems. The ambient temperature during test runs shall be not less than 15 °C (59 °F).
- 8.1 Chain Saws**
- 8.1.1 PREPARATION
- 8.1.1.1 Mount the test unit to the calibrated loading device with the bar clamp.
- 8.1.1.2 Weld or braze surface probes to all points found by the methods described in 6.1 and 6.2 where the test plane touches any part of the muffler surface. Use spark plug or cylinder head thermocouples for all tests.
- 8.1.1.3 Prepare a fresh fuel and oil mixture per the manufacturer's recommendations $\pm 2\%$.
- 8.1.1.4 Construct the contact planes as described in Section 6.
- 8.1.1.5 Run the test engine until it reaches operating temperature. Set loading device for the best power speed stated by manufacturer. Adjust the high-speed mixture jet adjustment screw setting to maximum torque at best power, then back it out slightly to allow for proper lubrication. Adjust the load to maintain the head temperatures below manufacturer's maximum head temperature limit.

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8.1.1.6 Using a portable, hand-held, thermocouple probe, crisscross the plane surfaces to find the hottest spot. Mount a thermocouple probe to monitor the exhaust gas temperature during the test at this location.

8.1.2 TEST

8.1.2.1 Run the test engine at best power speed for at least 3 min, simultaneously recording test data.

NOTE—If engine head temperature continues to rise after 3 min, recheck the high-speed mixture setting and repeat.

8.1.2.2 Increase speed slowly by 1000 rpm above best power and run for at least 3 min, simultaneously recording test data.

8.1.2.3 Decrease speed slowly to 1000 rpm below best power in steps of 500 rpm. Record torque for each step. When the 2000 rpm speed reduction has been reached, run for 3 min simultaneously recording test data.

8.1.2.4 Increase speed slowly to best power speed and run for at least 3 min, simultaneously recording test data.

EXAMPLE—If best power is 8000 rpm, Test 8.1.2.2 would be conducted at 9000 rpm, Test 8.1.2.3 at 7000 rpm, and Test 8.1.2.4 at 8000 rpm.

8.2 String Trimmers and Brush Cutters

8.2.1 PREPARATION

8.2.1.1 Instrument test unit to measure speed and temperatures per Section 7. Document the method of loading.

8.2.1.2 Run test unit with cutting head attachment until the head reaches operating temperature.

8.2.1.3 Establish operating engine speed by loading and adjusting the high-speed mixture jet for best power speed, or use the best power speed specified by the manufacturer.

8.2.1.4 Adjust the high-speed mixture adjustment screw setting to maximum best power speed, then back out slightly to allow for proper lubrication at maximum power.

8.2.1.5 Adjust the load to maintain the head temperature within 17 °C (30 °F) below the manufacturer's maximum head temperature limit.

8.2.2 TEST

8.2.2.1 Run the test engine at best power speed for at least 3 min, simultaneously recording test data.

NOTE—If engine head temperature continues to rise after 3 min, recheck the high-speed mixture setting, adjust and repeat.

8.2.2.2 Increase speed slowly to 1000 rpm above best power and run for at least 3 min, simultaneously recording test data.

8.2.2.3 Decrease speed slowly to 1000 rpm below best power and run for at least 3 min, simultaneously recording test data.

8.2.2.4 Increase speed slowly to best power speed and run for at least 3 min, simultaneously recording test data.

EXAMPLE—If best power is 7000 rpm, Test 8.2.2.2 would be conducted at 8000 rpm, Test 8.2.2.3 at 6000 rpm, and Test 8.2.2.4 at 7000 rpm.

8.3 Blowers

8.3.1 PREPARATION

8.3.1.1 Instrument the test engine to measure speed and temperatures per Section 7.

8.3.1.2 Run the test engine until the engine is at operating temperature.

8.3.1.3 To check the operational speed, set the unit up without tubes or nozzles. (Blowers are constructed to run at full throttle with very little load on the engine.) Blowers usually run at a much higher speed than the best power speed.

8.3.1.4 Run unit for 3 min, adjust high-speed mixture adjustment screw for the best operational power speed, then back out slightly to allow for proper lubrication.

8.3.2 TEST

8.3.2.1 Run test unit at wide open throttle at least 3 min without tubes or nozzles, simultaneously recording test data.

NOTE—If engine head temperature continues to rise after 3 min, recheck the high-speed mixture setting, adjust and repeat.

8.3.2.2 Increase speed by 1000 rpm above the speed found in 8.3.2.1, by partially covering the blower intake or discharge port. Run at least 3 min, simultaneously recording test data.

8.3.2.3 Run test unit at wide open throttle at least 3 min without tubes, nozzles, or blocking the blower intake or discharge port, simultaneously recording test data.

EXAMPLE—If the wide open throttle speed is 7000 rpm for Test 8.3.2.1, then run Test 8.3.2.2 at 8000 rpm and Test 8.3.2.3 at 7000 rpm.

8.4 Hedge Trimmers and Cutoff Saws

8.4.1 Instrument test unit to measure speed and temperatures per Section 7.

8.4.2 Run the test engine for at least 3 min, simultaneously recording test data.

8.4.3 TEST—Run the test with the throttle wide open. (Hedge trimmers and cutoff saws are constructed to run at full throttle with very little load on the engine. Hedge trimmers usually run at a much higher speed than the peak torque speed.)

8.5 **Other MSE Configurations**—Test methods for configurations other than those listed previously may be developed by agreement between the testing agency and the manufacturer with respect to the limit dictated by Appendix A of this document.

9. Spark Arrester Effectiveness Test

9.1 **Introduction**—This test method determines the proportion of carbon particles of two sizes retained by the spark arrester portion of the exhaust system. By definition, an arrester is 100% effective for the retention of carbon particles larger than the largest actual opening of its screens or baffles through which all gases pass. The spark arrester effectiveness test is not required for carbon particle retention of the sizes larger than the actual screen or baffle openings. Consequently, no spark arrester effectiveness test is required for screen type arresters that pass the screen test, as described in Section 5.

9.2 Test Position of Spark Arrester—Test the spark arrester in the position where it is the least effective. This position is determined by attaching the spark arrester to a short length of hose from the air source. The hose ID should be equal to or larger than the spark arrester inlet.

Establish conditions described in 9.5.2 and 9.5.3 and then move spark arrester to different positions while watching for the emission of test carbon particles. The position at which the largest number of particles escape is the position of least effectiveness.

9.3 Test Apparatus—The test apparatus consists of a suitable blower with air directed through the testing apparatus, a flowmeter, a flow controlling valve or orifice, a back pressure manometer, a screened exhaust vent, a carbon injector, and a trap for collecting the particles. Figure 3 shows one acceptable arrangement with some optional features.

9.3.1 FLOWMETER—Use a flowmeter of an established design, such as a calibrated orifice. The indicated flow shall be within $\pm 5\%$ of actual.

9.3.2 INJECTING MECHANISM—Inject the test carbon with a feeder mechanism that does not crush or grind the material or affect the normal flow of air through the apparatus, located approximately as shown in Figure 3. Inject test carbon into the airstream at uniform rate over a period of $15 \text{ min} \pm 5 \text{ min}$.

9.4 Test Carbon—Make separate test runs using SAE J997 test carbon.

9.4.1 Use $5 \text{ g} \pm 0.1 \text{ g}$ of carbon used for each test run.

9.4.2 Test carbon may be reused if the guidelines given in SAE J997 are followed.

9.5 Back Pressure and Flow

9.5.1 Make provision for measuring back pressure (differential pressure from intake to discharge of the arrester) and flow rate through the arrester.

9.5.2 Unless 9.5.3 applies, test the spark arrester at the assigned maximum flow capacity and at the assigned flow capacity with both coarse and fine test carbon.

9.5.2.1 *Establishment of Assigned Flow Capacity and Assigned Maximum Flow Capacity*—The assigned maximum flow capacity is the constant airflow rate resulting when a spark arrester is subjected to a pressure differential from intake to discharge of 6.9 kPa (1.0 lbf/in² gage) without test carbon being injected. The assigned flow capacity is the constant airflow rate resulting when a spark arrester is subjected to a pressure differential of 3.5 kPa (0.5 lbf/in² gage).

9.5.3 Some spark arresters may clog before the entire 5 g of test carbon is injected into the arrester. In these instances, use the following procedure:

9.5.3.1 *Condition 1*—Initially establish an airflow to cause a back pressure of 6.9 kPa (1.0 lbf/in² gage). Then allow the back pressure to build up to 9.0 kPa (1.3 lbf/in² gage). Once the 9.0 kPa (1.3 lbf/in² gage) is reached, maintain this pressure for the balance of the test.

9.5.3.2 *Condition 2*—Initially establish an airflow to cause a back pressure of 3.5 kPa (0.5 lbf/in² gage). Then allow the back pressure to build up to 5.5 kPa (0.8 lbf/in² gage). Once the 5.5 kPa (0.8 lbf/in² gage) is reached, maintain this pressure for the balance of the test.

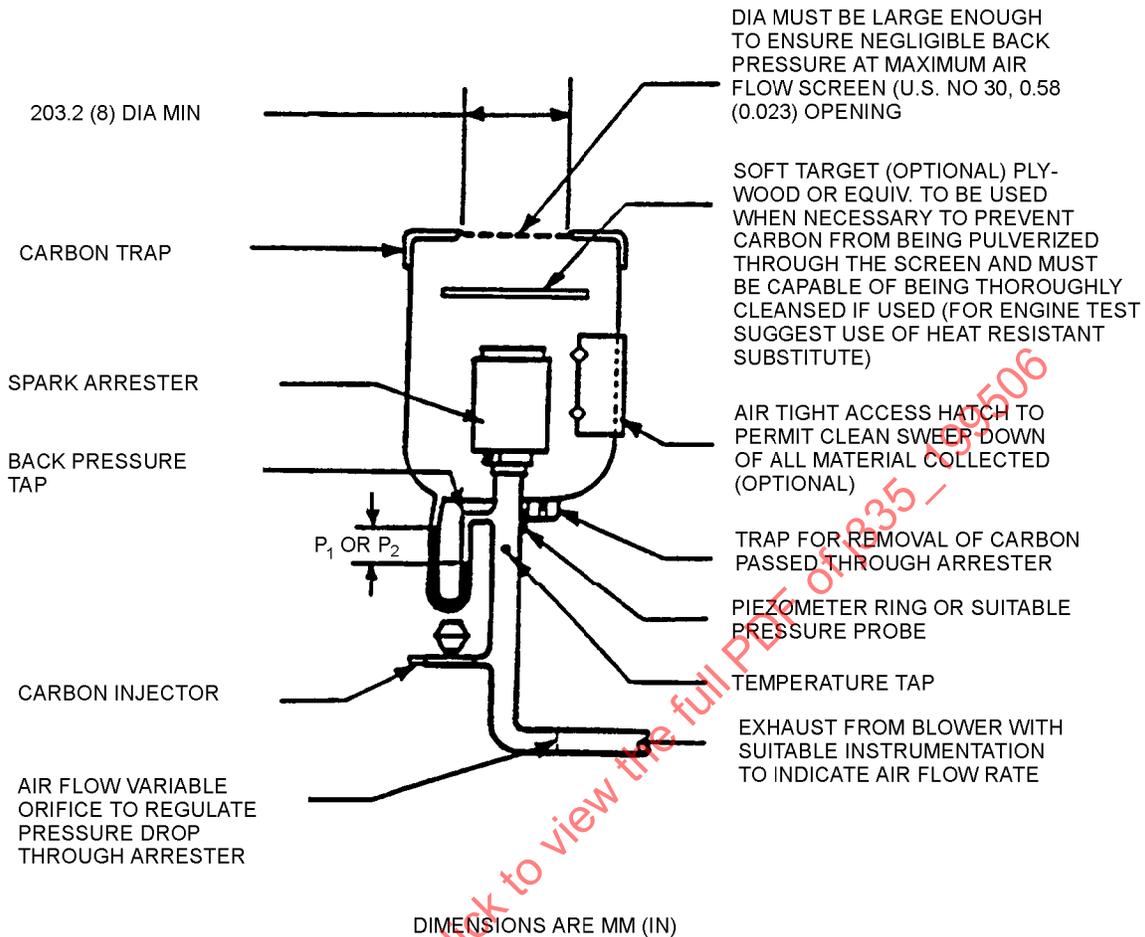


FIGURE 3—SPARK ARRESTER TEST APPARATUS

9.6 Carbon Particle Collection—Carefully brush all carbon inside the test apparatus which has escaped through the spark arrester during each run into the trap and then hand-sieve lightly on a U.S. Standard No. 30 600 μm opening (0.023 in) sieve. Weigh the carbon particles retained.

9.6.1 DETERMINATION OF ARRESTING EFFECTIVENESS—Use Equation 1 to determine arresting effectiveness for both SAE fine and SAE coarse carbon:

$$\% \text{ effectiveness} = \frac{\text{Weight used} - \text{Weight of Carbon Retained on No. 30 U.S. sieve (600 } \mu\text{m)}}{\text{weight used}} \times 100 \quad (\text{Eq. 1})$$

9.6.2 Use Equation 2 to determine the arrester's combined effectiveness:

$$\% \text{ combined effectiveness} = \frac{\% \text{ effectiveness with fine} + \% \text{ effectiveness with coarse}}{2} \quad (\text{Eq. 2})$$