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SAE J350 OCT88

Spark Arrester Test Procedure for Medium Size Engines

SAE Recommended Practice
Revised October 1988

Submitted for Recognition as an American National Standard

The Engineering Society For Advancing Mobility Land Sea Air and Space ®
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HIGHWAY VEHICLE PRACTICE

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SAE J350

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Ø SPARK ARRESTER TEST PROCEDURE FOR MEDIUM SIZE ENGINES

1. PURPOSE:

This recommended practice provides a method of testing to evaluate spark arresters for compression ignition or spark ignition internal combustion engines. It is not intended to establish the performance level required for adequate fire protection, nor does it cover applications requiring flame arresting, exhaust gas cooling, or isolation from explosive gases.

2. SCOPE:

This recommended practice establishes equipment and procedures for testing spark arresters used on medium-size, single-position internal combustion engines, normally used in transportable, stationary, and vehicular applications, such as highway trucks, agricultural tractors, industrial tractors, other mobile equipment, and motorcycles. This recommended practice provides two methods of testing (laboratory testing and engine testing) which may be used to evaluate a spark arrester. It also includes special requirements for screen type devices and an endurance test procedure for screen type spark arresters.

2.1 Spark Arrester Application: Spark arresters qualified by an engine test should be used on only engines of the same design and size (or smaller) and which do not exceed the calculated flow rate of the test engine by more than 15%. Calculated flow rate shall be determined at maximum power engine speed or at maximum governed engine speed, whichever is lower.

This recommended practice has been established to cover most medium sizes and type of engines and engine applications. Arresters tested under this procedure should not be used above their rated flow unless tested and found to be adequately efficient at the intended flow.

3. TEST EQUIPMENT REQUIREMENTS:

3.1 Laboratory Test:

3.1.1 Test Equipment: The test unit consists of a blower with air directed through the metering instruments, a carbon injector, the test spark arrester, and a trap for collecting particles, and a method of measuring the gas flow through the spark arrester. The apparatus shall permit mounting of arresters in all positions in which they may be used and shall discharge into the positive trap in a manner similar to that shown in Fig. 1.

3.1.2 Test Carbon: Test carbon shall conform to SAE J997.

3.1.3 Carbon Injector: The test carbon shall be injected by a feeder mechanism that does not crush or grind the carbon or affect the normal flow of air through the apparatus. It shall be located approximately as shown in Fig. 1.

3.1.4 Differential Pressure: The test equipment shall include a piezometer ring, probe, or other method for monitoring pressure at the inlet of the arrester. If a piezometer ring is used, it shall be as specified in SAE J726. The differential pressure shall be measured between the piezometer ring or probe and the pressure tap on the discharge side of the arrester or in the side of the positive trap chamber. (See Fig. 1.)

A piezometer ring or probe calibration run shall be made over the anticipated airflow range, with no spark arrester in place. The indicated pressure recorded shall be plotted and the resulting calibration curve shall be used to correct data recorded during subsequent tests. At each test point, the flow rate through the arrester shall be held constant during the carbon feed cycle.

3.1.5 Flow Measurements: Any method which measures the gas flow through the spark arrester, with an accuracy of ±5% of the actual value, may be used.

3.2 Engine Test: When the spark arrester is to be tested on an engine, the equipment used shall be similar to those described in Section 3.1. Facilities for loading the engine shall be provided. The engine exhaust shall be used in place of the blower air supply. The measurement of gas exhaust flow is not required. Gas temperature shall be that normally produced by the engine after stabilization under conditions given in paragraph 4.2.4.

4. TEST PROCEDURE:

4.1 Laboratory Test:

4.1.1 Setup and Pre-Test Checks: Test equipment shall be arranged in a general configuration similar to that shown in Fig. 1. The arrester shall be mounted to the equipment in the position specified by the arrester manufacturer. The inlet duct shall be sized to fit the arrester as in a normal installation. The following checks of the test equipment shall be made with no spark arrester installed. A straight pipe equal in length and inlet inside diameter to that of the test arrester shall be installed.

4.1.1.1 Determine system back pressure, with air delivery flow from 10% of that flow which would occur at 1 lbf/in^2 gage with the spark arrester installed, to maximum expected. See paragraph 4.2.4.

4.1.1.2 Ensure that there is no pulverization of the test carbon caused by the injection apparatus or in the positive test trap by running a sample of each test carbon at the highest flow point.

4.1.1.3 Check that the outlet screen is of sufficient cross-sectional area to maintain minimum back pressure in the test apparatus discharge.

4.1.1.4 Sample Run: To establish the amount of test carbon to be used for each test, make a sample run. This consists of operating the test equipment with the spark arrester installed, at a back pressure of 1 lbf/in^2 gage carbon being injected, for a period of 12 minutes. At the end of 12 min, the airflow and temperature are recorded. From this information, the corrected air flow is calculated. See paragraph 5.2. The amount of test carbon to be used for each test run is the corrected flow at 1 lbf/in^2 gage times 0.2 grams. A minimum of 25 g and a maximum of 200 g shall be used.

4.1.2 Test: Run the test as follows:

4.1.2.1 Carbon: Prepare sufficient samples of each size of test carbon. See paragraph 4.1.1.4.

4.1.2.2 Duration of Test: Inject test carbon into the air stream at a uniform rate over a period of 15 ±5 minutes.

4.1.2.3 Flow Points: Operate the test rig at 10, 32.5, 55, 77.5 and 100% of the flow at 1 lbf/in^2 gage differential pressure, with each Fine and Coarse carbon. Record data specified in paragraph 4.4.1. Calculate and plot the results as specified in Fig. 2. Any points which do not fall on a smooth curve should be rejected and the data re-run. Data may be recorded at higher flows when potential arrester applications indicate a need for this additional data. Any effectiveness data within 2% of the minimum allowable is justification for additional intermediate data test points.

4.1.3 Data to be collected (for each flow rate):

4.1.3.1 Weight of test sample (W_s) for both SAE coarse and SAE fine carbon tests, grams.

(Under low flow rate conditions, stack air velocity may be insufficient to carry all of the test sample into the arrester. In these instances, W_s shall be determined by weighing the total of collected material found in the positive trap chamber and cleaned out of the arrester.)

4.1.3.2 Weight of carbon in the positive trap chamber that is retained on a U.S. Standard No. 30 Sieve (W_t), gram. Record W_t (for coarse or fine carbon as applicable) for each individual run.

4.1.3.3 Air flow at test conditions, ft^3/m (dm^3s).

4.1.3.4 Air temperature at spark arrester inlet, F (C).

4.1.3.5 Pressure in the system without the spark arrester installed, at airflow rates per paragraph 4.2.4 (p_1), (lbf/in^2 gage).

4.1.3.6 Pressure in the system with spark arrester installed, (P_2), lbf/in^2 gage.

(With some arresters, back pressure and flow will vary widely during the 15-min test period. In these instances, maintain constant flow during the test period, and record both minimum and maximum back pressure. In plotting the flow curve, the average differential pressure shall be used. See Fig. 2.)

4.1.3.7 Differential pressure, P_A, equal to P_2-P_1.

4.2 Engine Test: The engine test is conducted on a facility for loading engines (dynamometer).

4.2.1 Setup: Test equipment shall be arranged in a manner similar to that shown in Fig. 1, with the exception that the engine exhaust shall be used as the air source rather than the blower. The arrester shall be mounted in the orientation that it is intended to operate on the engine and discharge into the positive trap.

4.2.2 Quantity of Carbon: See paragraph 4.1.1.4.

4.2.3 Duration of Test: See paragraph 4.1.2.2.

4.2.4 Flow Points: Data shall be recorded separately for each size carbon, at the following operating conditions:

4.2.4.1 No load and governed high idle speed.

4.2.4.2 100% rated load at rated speed.

4.2.4.3 50% of attainable load at one-half rated speed.

4.2.4.4 Where applicable (such as for trucks), 80% of rated net load at rated speed.

4.2.5 Data: Data to be obtained: (See Fig. 3.)

4.2.5.1 Engine speed (rpm).

4.2.5.2 Engine load, hp (W).

4.2.5.3 Back pressure induced by the spark arrester, lbf/in^2 gage (Pa).

4.2.5.4 Gas temperature at the inlet of the spark arrester, F (C).

4.2.5.5 Weight of each size test carbon used, gram.

4.2.5.6 Weight of each size test carbon retained in the trap that will not pass a U.S. No. 30 sieve or equivalent, gram.

4.3 Special Requirements for Screen Type Devices:

4.3.1 Effective exhaust area of screen (total area of all screen openings) shall not be less than 200% of the total exhaust port area.

If it is necessary to clean the spark arrester screen, the time of such cleaning shall be recorded. (See paragraph 4.4.1.6.) No screen cleaning shall be allowed during the final 12.5 h of the 50-h period. Since the final examination is to determine qualification status of the arresting unit, it is imperative that the screen and other components not be cleaned or altered in any way following completion of the test.

4.3.2 Screen material shall be heat and corrosion resistant. The screen component shall provide a minimum of 50 h of service life when tested in accordance with the endurance test for screen type spark arresters. See paragraph 4.4.

4.4 Endurance Test for Screen Type Spark Arresters: The arrester shall be mounted as specified by the arrester manufacturer on an engine of the type and maximum size for which the arrester is to be used. Engine size shall be determined by the maximum calculated flow rate. If the arrester is intended for both two- and four- stroke cycle applications, separate tests shall be conducted for each type of engine.

The test shall be conducted for a minimum of 50 h, which need not be continuous. A 1-h cycling period, representative of actual operating conditions, including idle at no load through maximum operating engine speed at full load, shall be conducted continuously throughout the entire 50-h period. Manufacturer's recommended air-to-fuel ratios shall be observed. Engine manufacturer's recommended oil-to-fuel ratios shall be observed for all two-stroke cycle tests.

4.4.1 During the 50-h test, the following data shall be recorded at increments of not more than 2 h:

4.4.1.1 Operating time.

4.4.1.2 Engine speed.

4.4.1.3 Temperature in screen area.

4.4.1.4 Engine load or output horsepower.

4.4.1.5 Exhaust back pressure.

4.4.1.6 Time and circumstance of any part failure or malfunction, including any required screen cleaning.

4.4.2 The following shall be recorded once for each arrester:

4.4.2.1 Complete information on the engine, including make, model, serial number, fuel used, etc.

4.4.2.2 A description of the test setup, including photographs.

5. CALCULATIONS:

5.1 Spark Arresting Effectiveness Formula:

$$\eta = \frac{(W_s - W_t) \times 100}{W_s}$$

where: η = spark arresting effectiveness, %

5.2 Exhaust Gas Flow Formula: (paragraph 4.2.2)

$$\text{Flow in cfm} = W_m \times \frac{1}{V} = W_m \times \frac{T + 460}{0.6523 \times P}$$

$$\left(\text{Flow in } dm^3/s = W_m \times \frac{1}{V} = W_m \times \frac{T + 273}{3.49 \times P}\right)$$

where: W_m = airflow determined by standard laboratory instrumentation or by airflow as specified by the engine manufacturer, lb/min (g/s)

V = specific weight of flowing gas, lb/ft^3 (g/m^3)

P = gas pressure at the inlet of the spark arrester, lbf/in^2 gage (kPa)

T = gas temperature at the inlet of the spark arrester, °F (°C)

6. PRESENTATION OF RESULTS:

6.1 Laboratory Test: Test results shall be presented graphically as shown in Fig. 2. In general, all tests shall be carried to a flow at which the differential pressure induced is 1 lbf/in^2 gage. Tests may be carried to greater flows when that information is required. Curves of effectiveness and differential pressure shall be presented as shown.

6.2 Engine Test: Engine test results shall be recorded in tabular form, as shown in Fig. 3, including engine speed and load, spark arresting effectiveness with each carbon size, and differential pressure at each data point.

The phi (Ø) symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

APPENDIX A

A1. ARRESTER PERFORMANCE:

When required performance levels are established, consideration should be given to the area in which the engine is operating. For example, in areas where daytime relative humidity of the atmosphere is below 30% for relatively long periods of time and there is considerable combustible material adjacent to the engine, the best spark arrester should be utilized. In areas of high humidity and little or no combustible material, spark arresters of lower ratings could be employed.

A2. LABORATORY TEST:

Under normal operating conditions, taking into account the speed of engine and exhaust flow rate, a spark arrester having an effectiveness of at least 80% with both fine and coarse carbon as determined by the method of this standard is considered, by most authorities, adequate for most conditions and areas.

A3. ENGINE TEST:

Experience has shown that at flows causing back pressure up to 1 lbf/in^2 gage, 90% effectiveness by the engine test is equivalent to 80% by the laboratory test, with both carbon sizes.

In applications where back pressure above 1 lbf/in^2 gage is developed, it is essential that additional testing be completed at the higher flow rate necessary to develop the actual maximum back pressure.

Arresters meeting this standard should not be expected to arrest sparks adequately when tilted more than 45 deg from their normal operating position.

APPENDIX B

B1. QUALIFICATIONS FOR APPROVAL:

A spark arrester is "qualified" under this standard if:

B1.1 The arrester demonstrates arresting effectiveness equal to or greater than those shown in Appendix A of this standard throughout the flow range for which qualification is sought.

B1.2 The arrester is easily cleaned (if cleaning is necessary).

B1.3 The arrester has a minimum service life of 1000 h, or a service life equal to that of the engine if a visual examination of the internal components is not possible, or, in the case of a screen type arrester, 100 hours.

B1.4 Arrester is identified by appropriate name, trademark, or model number.

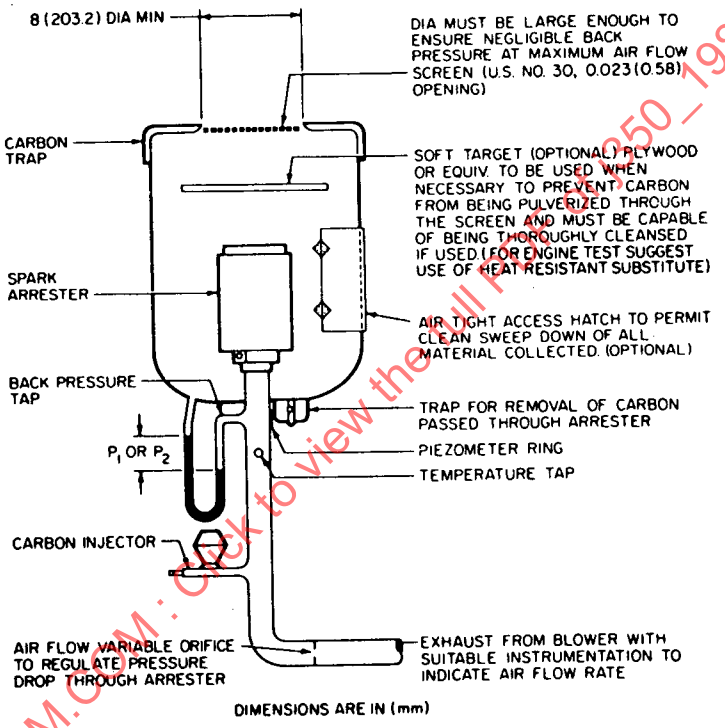

FIGURE 1 - Suggested Test Apparatus

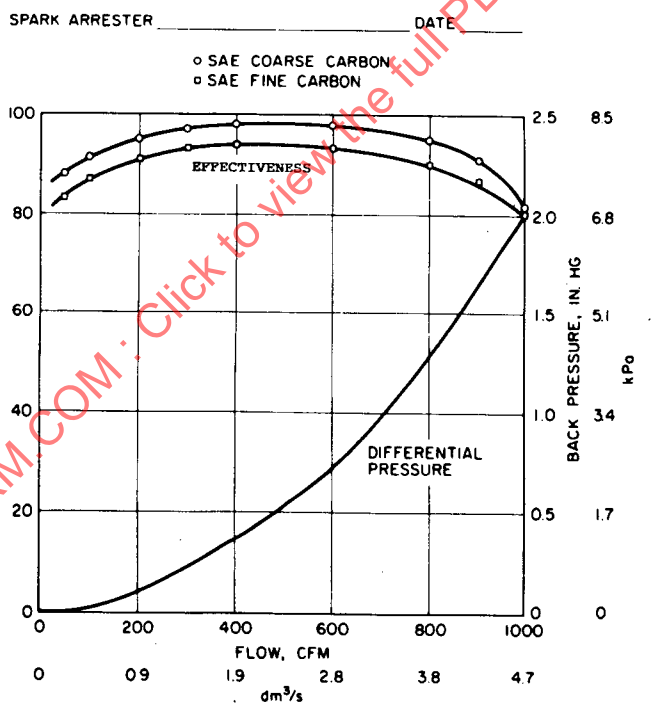

FIGURE 2 - Data Presentation