

Ø SPARK ARRESTER TEST PROCEDURE FOR LARGE SIZE ENGINES

1. PURPOSE:

The purpose of this SAE Recommended Practice is to provide a standard method of testing to evaluate spark arresters or turbochargers as spark arresters for use with compression ignition internal combustion engines.

This document provides a method to evaluate the effectiveness of various spark arresters, but is not intended to establish the performance level required for adequate fire protection (see Appendix 2).

2. SCOPE:

This recommended practice establishes equipment and procedures for the evaluation of the effectiveness and other performance characteristics of spark arresters or turbochargers used on the exhaust system of large engines normally used in railroad locomotives, stationary power plants, and other similar applications. This recommended practice does not cover applications requiring flame arresting, exhaust gas cooling, or isolation from explosive gases. Two testing methods are presented; a laboratory test using ambient air (cold test) and an engine test using exhaust gases (hot test). The engine test (hot test) is preferred. Arresters tested by this recommended practice can be expected to perform as tested when tilted no more than 45 deg from their normal position. Test results from a spark arrester or turbocharger evaluated by an engine test can be applied to different engines of similar design, provided the data shows it to be effective in the applicable flow ranges.

Certain design and performance characteristics, which represent current requirements by regulatory agencies for qualification and approval under this recommended practice, are listed in the Appendix.

Note: This illustration is intended to be general in nature, and does not represent any particular brand or manufacturer to the exclusion of others.

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3. PROCEDURE:

3.1 Apparatus:

3.1.1 Cold Test: The apparatus shall consist of a suitable blower, air plenum, air flow metering instruments, spark arresters carbon injector device, and positive trap for collecting the particles. Fig. 1 depicts a multi-inlet device, but a similar apparatus may be used to test single inlet devices. The apparatus shall be operated to its maximum flow rating as defined in Section 6 and determined from Fig. 3 or 3A to determine its capability. If the apparatus cannot attain the desired flow level, the data is acceptable, but additional tests at any required higher flows must be obtained on appropriate equipment such as on the actual engine application.

3.1.2 Hot Test: The apparatus is identical, except that the engine exhaust system is substituted for the blower.

3.2 Test Carbon: All test carbon used shall conform with the provisions of SAE J997. Except as allowed by 3.5.2, each test flow point shall be run using both fine and coarse test-carbon.

Total test carbon injected, per Fig. 1, shall be 100 g per engine cylinder. Single inlet devices shall have a minimum of 400 g of carbon injected.

3.3 Back Pressure: Back pressure shall be measured during each run at each flow, at the inlet of or in each manifold leg, during both hot and cold tests. A static pressure probe, such as illustrated in Fig. 1, shall be used.

3.4 Injection Rate: Test carbon shall be injected into the inlet or each manifold leg as applicable for all flow rates tested at a uniform rate during a period of 15 ± 5 minutes.

3.5 Flow Range:

3.5.1 Cold Test: The arrester shall be checked for efficiency and back pressure at not less than five points between 30 and 100% of the rated flow of the arrester. Rated flow is defined as the calculated flow range for the maximum engine size application as determined per Fig. 3 or 3A, or stated by the engine manufacturer. Note that maximum engine size application will be limited by maximum allowable back pressure requirements. One point shall be at 100% of rated flow, the remaining points shall be approximately evenly spaced relative to flow with the lowest point at approximately 30% of rated flow.

3.5.2 Hot Test: The arrester shall be checked for efficiency and back pressure at all numbered throttle positions. Where eight or more numbered throttle positions are involved, alternating carbon size (fine and coarse) may be used in lieu of testing each throttle position with both carbon sizes. Low efficiency at any setting with one carbon size warrants further test with the other carbon size.

3.6 Data: For each test point (flow and carbon size), obtain the following data:

3.6.1 Weight of carbon injected, gram, to an accuracy of 0.1 gram.

3.6.2 Weight of carbon retained in the trap, gram, to an accuracy of 0.1 gram.

Contents of stack trap should be sieved lightly on No. 30 (600 μ m) U.S.A. Standard Sieve before calculating efficiency. Test carbon particles reduced in size to the point where they will pass a No. 30 (600 μ m) U.S.A. Standard Sieve are considered to be destroyed and, therefore, are discarded, contributing to the arrester's efficiency.

3.6.3 Back Pressure

3.6.4 Flow

3.7 Effectiveness: Calculate the effectiveness of the arrester at each test point using the following formula:

$$\% \text{ Effectiveness} = \frac{[(\text{Wt. of carbon sample}) - (\text{Wt. of carbon found in stack trap})]}{\text{Wt. of carbon sample}} \times 100$$

3.8 Report: Plot the data and calculated efficiency as shown in Fig. 2.

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APPENDIX

A1. TURBOCHARGERS:

Turbochargers are generally very effective spark arresters.

A2. PERFORMANCE REQUIREMENTS:

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.

A3. HOT TEST:

Cold Test Equivalence - Empirical data indicates that 80% efficiency using the cold test procedure is approximately equivalent to 90% efficiency using the hot test procedure.

A4. BACK PRESSURE MEASUREMENTS:

When selecting or testing spark arresters, the engine manufacturer's back pressure limits should be considered. If no such limits are stated, back pressure should not exceed 3.5 in Hg (11.8 kPa) average in all manifold inlet legs and should not exceed 4 in Hg (13.5 kPa) in any single leg. Single inlet devices, when installed on a manifold stack, should not cause manifold inlet legs to exceed the maximum allowable limits.

Most regulatory agencies require back pressure to be measured by the hot test method.

A5. PERFORMANCE SPECIFICATIONS:

Most regulatory agencies in the U.S. which require spark arresters, require spark arresters to meet the following requirements:

- A5.1 Effectiveness: The arrester shall have effectiveness of 80% by the cold test or 90% by the hot test.
- A5.2 Cleaning Trap: The arrester, if of the retention type, shall have provisions for the easy disposal of the accumulated particles.
- A5.3 Spark Trap Capacity: The capacity of spark retention traps, if used, shall be not less than 200 in³ (3277 cm³) per trap, or not less than 30 in³ (492 cm³) per cylinder.

- A5.4 Marking and Labeling: Each arrester shall be permanently marked with manufacturer's model designating, serial number or date, and a trademark or other identification of manufacturer.
- A5.5 Warranty: The arrester manufacturer shall warrant that the arrester will maintain the required spark arresting efficiencies during the warranty period.

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The phi (ϕ) 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.

RATIONALE:

After extensive discussion, the subcommittee decided that all that was warranted by way of revision was an editorial cleanup. The suggestion of the Engine Committee to change Fig. 1 to reflect a more general locomotive engine, though championed by the subcommittee chairman, was respectfully declined.

Though SAE J342 concentrates on the testing of a specific group of railroad locomotive diesel engines, namely the 567 and non-turbo supercharged 645 series engines manufactured by the Electro-Motive Division (EMD) of the General Motors Corporation, this is both justified and required in view of both the legislated requirements that a large number of these engines be equipped with approved spark arresters and the very large number of these engines produced and still in service. By our count the total number of locomotives in the U.S. employing these EMD engines is 21 140. Of this number, about 70% or 15 000 locomotives are currently equipped with approved arresters that meet the requirements of SAE J342. Thus, any changes that would de-emphasize the test equipment and procedure required for the testing of this very important segment of large engines would be self defeating.

There is little question that SAE J342 is acceptable to all governing agencies since it is patterned after and grew from the U.S. Forest Service 5100-1A Spark Arrester Test Procedure. It is also very similar to and consistent with the procedure and requirements adopted by the Association of American Railroads.

Thus, the subcommittee was unanimous on this point.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

APPLICATION:

This recommended practice establishes equipment and procedures for the evaluation of the effectiveness and other performance characteristics of spark arresters or turbochargers used on the exhaust system of large engines normally used in railroad locomotives, stationary power plants, and other similar applications. This recommended practice does not cover applications requiring flame arresting, exhaust gas cooling, or isolation from explosive gases. Two testing methods are presented; a laboratory test using ambient air (cold test) and an engine test using exhaust gases (hot test). The engine test (hot test) is preferred. Arresters tested by this recommended practice can be expected to perform as tested when tilted no more than 45 deg from their normal position. Test results from a spark arrester or turbocharger evaluated by an engine test can be applied to different engines of similar design, provided the data shows it to be effective in the applicable flow ranges.

REFERENCE SECTION:

SAE J997 JAN80, Spark Arrester Test Carbon