Spark Arrester Test Procedure for Large Size Engines — SAE J342 NOV80

SAE Recommended Practice
Completely Revised November 1980

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PREPRINT

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SAE Recommended Practice

Report of the Engine Committee, approved June 1968, completely revised November 1980.

1. Purpose—The purpose of this SAE Recommended Practice is to provide a standard method of testing to evaluate spark arresters or turbochargers[1] as spark arresters for use with compression ignition internal combustion engines.

This document provides a method to determine acceptability of various spark arresters by regulatory agencies, but is not intended to establish the performance level required for adequate fire protection.[2]

2. Scope—This recommended practice establishes equipment and procedures for the evaluation of the relative collection efficiencies 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 uniform testing methods are offered; a laboratory test using ambient air (cold test) and an engine test using exhaust gases (hot test), which may be used by spark arrester manufacturers, governmental bodies, and engine spark arrester users. Though the engine test (hot test) is preferred, approval can be sought based on the lab test (cold test) over the airflow range tested. Arresters meeting this standard should not be expected to adequately arrest sparks when tilted more than 45 deg from their normal operating position. Spark arresters or turbochargers qualified by an engine test can be applied to different engines of similar design without a complete retest, provided the data shows it to be effective in the applicable flow ranges. Additional test data may be obtained to determine effectiveness at higher or lower flow ranges.

Certain design and performance characteristics, which may be required by regulatory agencies for qualification and approval under this recommended practice, are listed in the Appendix.

3. Spark Arrester Test Procedure

3.1 Performance Rating and Testing

3.1.1 Arresting Efficiency—Cold Test—When cold tested, as outlined in paragraph 3.2.1, efficiency shall be the percent of SAE test carbon particles retained in the spark arrester trap or pulverized to sizes which pass through a No. 30 (600 μm) U.S.A. Standard Sieve—28 mesh, 0.0234 in (0.59 mm) opening, 0.0154 in (0.39 mm) diameter wire. When cold tested by means of a blower, the arresting efficiency shall be determined for 30—100% of the engine's exhaust flow rate.

3.1.2 Arresting Efficiency Hot (Engine) Test—When hot tested on an operating engine, as outlined in paragraph 3.2.2, efficiency shall be determined for all operating speeds, including idle. Methods described herein shall be used to determine either the spark arrester or turbocharger efficiency as a spark arrester.

3.2 Test Method

3.2.1 Cold Test—The apparatus shall consist of a suitable blower, air plenum, air metering instruments, spark arrester 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 unit must be tested to its maximum flow rating as defined in Section 6 and determined from Fig. 3 or 3A. If the apparatus used cannot attain the desired flow level, the data will be accepted, but additional tests at the required higher flows must be obtained on appropriate equipment such as on the actual engine application.

3.2.2 Hot (Engine) Test—When the spark arrester or the turbocharger itself is being tested on the engine, the equipment requirements will be quite similar to those described previously. The engine will be operated under its various load conditions. Test carbon will be injected into the exhaust gas stream (see Fig. 1).

4. Test Carbon—Test carbon will conform to SAE Standard J997, both fine and coarse grades.

5. Back Pressure Measurements—While provisions are made to measure the back pressure at the inlet or in each manifold leg, as applicable, the qualification for back pressure acceptance must be determined under the hot test conditions and should be measured with a static-pressure probe or equivalent instrumentation, as shown in Fig. 1. A typical back pressure curve is shown in Fig. 2.

6. Test Condition Range—When cold tested, 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 shall be 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. Arresters hot tested on engines, as described in paragraph 3.2.2, shall be tested 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 permitted in lieu of testing each throttle position with both carbon sizes. Low efficiency at any throttle setting with one carbon size warrants further test with the other carbon size. Plot test data as shown in Fig. 2.

7. Weight of Carbon Sample—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.

8. Duration of Test—Test carbon shall be injected into the inlet or each manifold leg as applicable for all flow rates at a uniform rate during a period of 15 min. A tolerance of ±5 min will be allowed.

9. Calculation of Efficiency

$$\%\text{ efficiency} = [(\text{Wt. of carbon sample})-(\text{Wt. of carbon found in stack trap}^{3})] \times 100 \div \text{Wt. of carbon sample}$$

10. Back Pressure on Engine—Engine exhaust back pressure is not to 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, must not cause manifold inlet legs to exceed the maximum allowable limits.

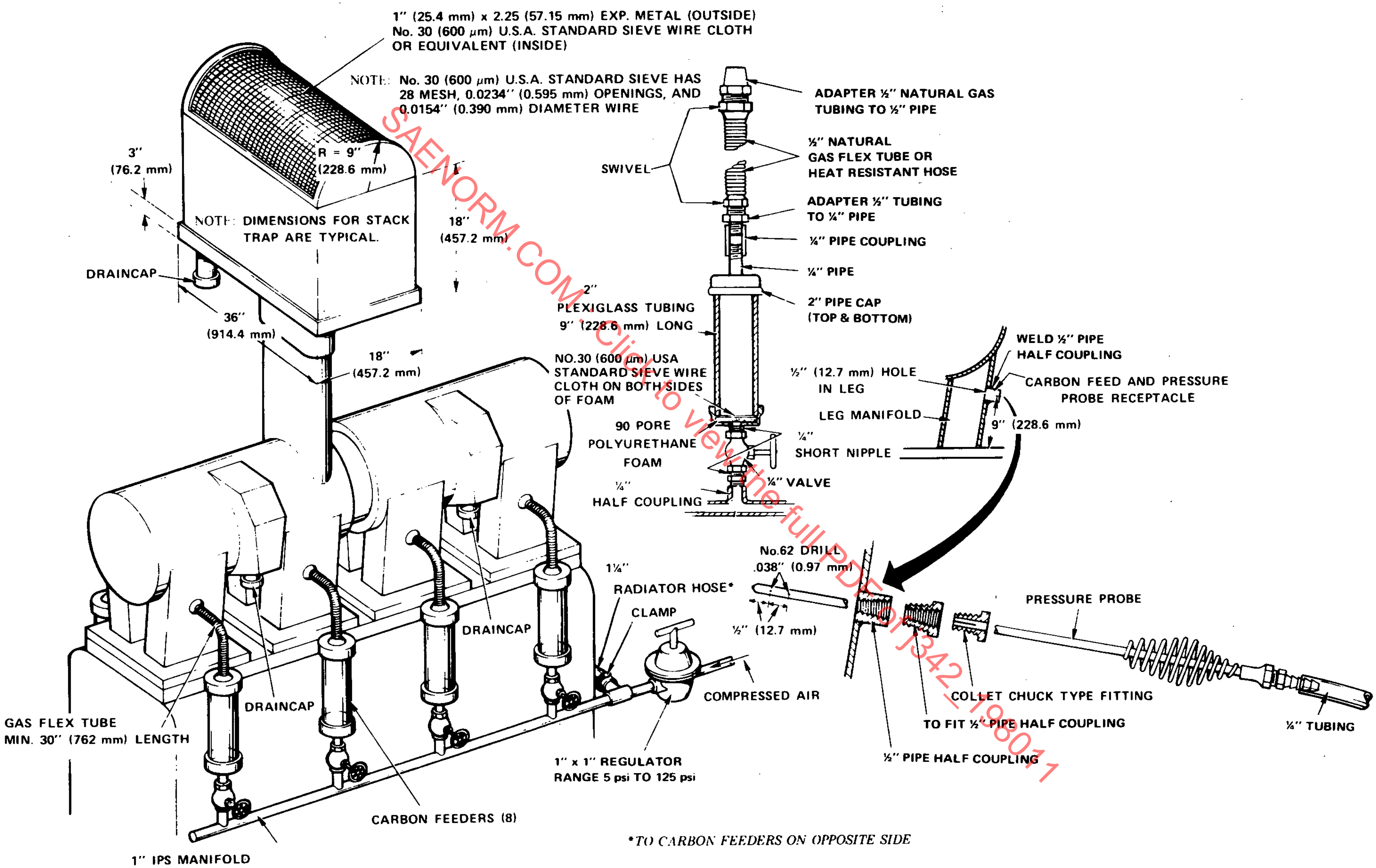
Note: Lower back pressure limits should be observed if required to comply with manufacturer's recommendations.

[1] Turbochargers are generally very effective spark arresters.

[2] 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.

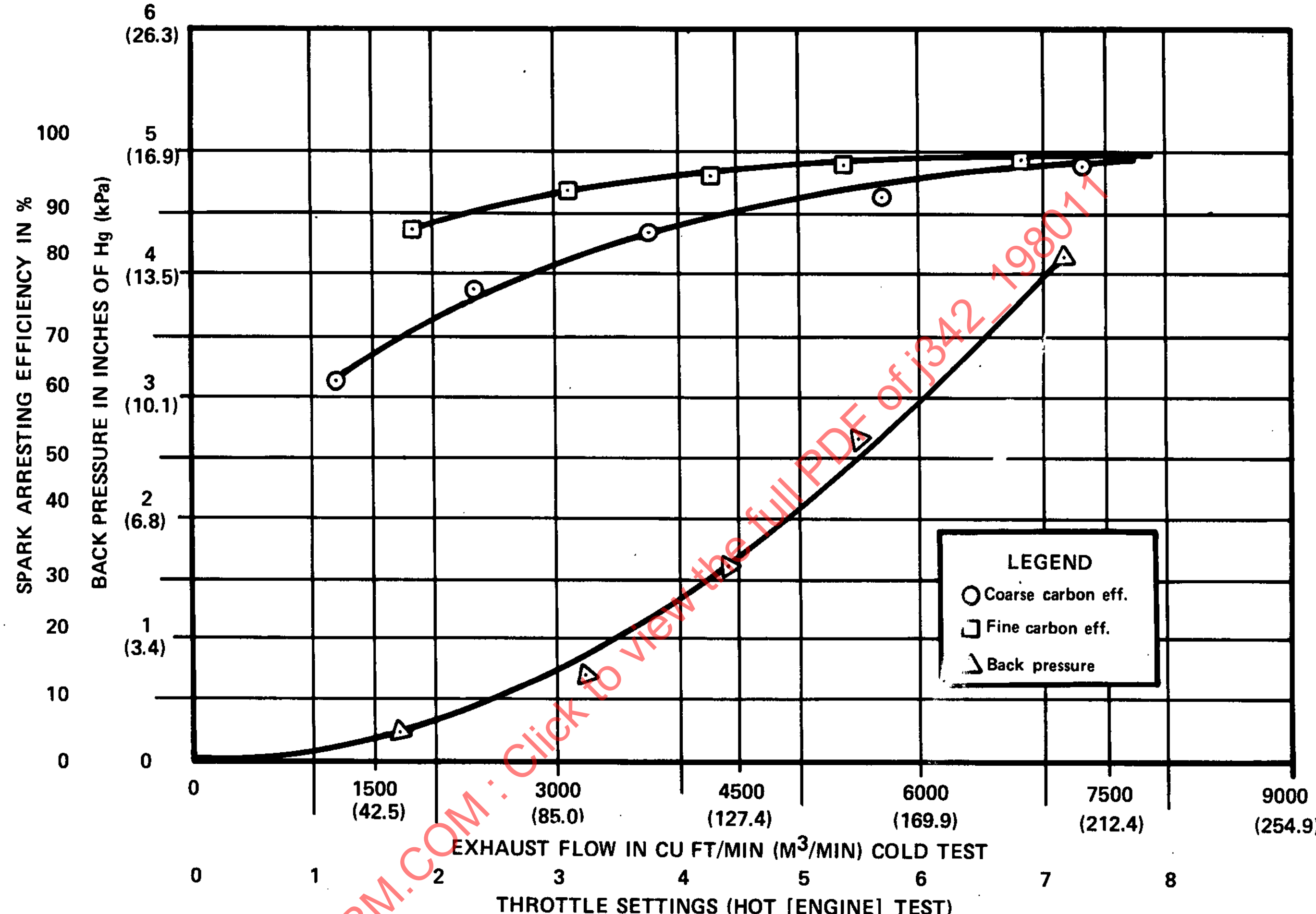
The ϕ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

[3] Contents of stack trap should be sieved lightly on No. 30 (600 μm) 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 μm) U.S.A. Standard Sieve are considered to be destroyed and, therefore, are discarded, contributing to the arrester's efficiency.



*TO CARBON FEEDERS ON OPPOSITE SIDE

FIG. 1



GRAPHIC PRESENTATION OF TEST DATA:

- Back pressure versus flow (or throttle setting)
- Efficiency versus flow (or throttle setting)

FIG. 2

EXHAUST FLOW IN CUBIC FEET PER MINUTE AT MAXIMUM RATINGS[a] FOR 4-CYCLE DIESEL ENGINES[b]

Engine Displacement (in^3)[c]	Revolutions per Minute												rpm[d] Differential
	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	
1	0	1	1	1	1	1	1	1	1	1	2	2	0
2	1	1	1	2	2	2	2	2	3	3	3	3	0
3	1	2	2	2	3	3	3	4	4	4	5	5	0
4	2	2	3	3	4	4	4	5	5	6	6	7	0
5	2	3	3	4	4	5	6	6	7	7	8	8	1
6	3	3	4	5	5	6	7	7	8	9	9	10	1
7	3	4	5	5	6	7	8	9	9	10	11	12	1
8	4	4	5	6	7	8	9	10	11	12	13	13	1
9	4	5	6	7	8	9	10	11	12	13	14	15	1
10	4	6	7	8	9	10	11	12	13	15	16	17	1
20	9	11	13	16	18	20	22	25	27	29	31	34	2
30	13	17	20	24	27	30	34	37	40	44	47	51	3
40	18	22	27	31	36	40	45	49	54	58	63	67	4
50	22	28	34	39	45	51	56	62	67	73	79	84	6
60	27	34	40	47	54	61	67	74	81	88	94	101	7
70	31	39	47	55	63	71	79	87	94	102	110	118	8
80	36	45	54	63	72	81	90	99	108	117	126	135	9
90	40	51	61	71	81	91	101	111	121	131	142	152	10
100	45	56	67	79	90	101	112	124	135	146	157	169	11
200	90	112	135	157	180	202	225	247	270	292	314	337	22
300	135	168	202	236	270	303	337	371	404	438	472	506	34
400	180	225	270	315	360	404	449	494	539	584	629	674	45
500	224	281	337	393	449	505	562	618	674	732	786	843	56
600	269	337	405	472	539	606	674	742	809	876	944	1011	67
700	314	393	472	550	629	708	786	865	944	1023	1101	1180	79
800	359	449	540	629	719	809	899	989	1079	1169	1258	1348	90
900	404	506	607	708	809	910	1011	1113	1213	1315	1415	1517	101
1000	449	562	674	786	899	1011	1124	1236	1348	1461	1573	1685	112

[a] Volumetric efficiency 80%; exhaust temperatures 900° F.
[b] For 2-cycle engines, multiply value by 3; for 2-cycle supercharged engines, multiply value by 4; for 4-cycle supercharged engines, multiply value by 1.25.
[c] 1 cm^3 = 0.061 in^3 (number of cubic centimeters x 0.061 = cubic inches).
[d] The "rpm Differential" column gives the difference between rpm columns for interpolation purposes. Entries are to the nearest whole number.

GENERAL—All chart values are proportional, so a flow can be calculated for a 1000-cubic inch engine by doubling the flow figure for an identical engine but with 500-cubic inch displacement. The same rule applies to revolutions per minute. Therefore, a flow rate can be calculated of a 3000 maximum rpm engine by doubling the flow value of an identical engine but with 1500 maximum rpm.

The chart may also be used like an interest table. If the engine has a cubic inch displacement of 438 at 2600 rpm, select readings from 400, 30, and 8 at 2600 rpm. The sum of these is the flow rate. When revolutions per minute fall between columns, that is, 1600 to 1800, 1800 to 2000, etc., take the next highest rpm column. To be more exact, interpolate by using the "rpm Differential" value.

EXAMPLE—A 4-cycle diesel engine has a total displacement of 633 in^3. If its maximum rpm is 2600, what is the maximum exhaust flow?

SOLUTION—600-cubic inch displacement at 2600 rpm = 876; 30 = 44; and 3 = 4; sum = 924.

FIG. 3