

Standard 5100-1d
February 2013

Superseding 5100-1c
September 1997

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
STANDARD FOR SPARK ARRESTERS
FOR INTERNAL COMBUSTION ENGINES

Beneficial comments and suggestions related to this standard should be addressed using the comment sheet at the end of this document. Remarks may be sent via electronic mail (mailroom_wo_sdtcd@fs.fed.us) or U.S. mail to the USDA Forest Service San Dimas Technology and Development Center, 444 E. Bonita Ave., San Dimas, CA 91773.

CHANGE DESCRIPTION RECORD

This is a complete revision. Numbered sections and appendixes no longer correspond to those in the previous revision. Major changes are listed below. Minor changes, which do not modify the intent of the standard are not listed. All references to specific test procedures have been removed in lieu of references to the established Society of Automotive Engineers (SAE) spark arrester test specifications.

Change	Reason
Added definitions section and introduced a list of definitions relevant to spark arrester exhaust systems	Clarity
Removed all mention of specific test procedures	The intent of standard 5100-1 is that it is a performance standard only. Specific test procedures are maintained in the SAE J350 and J335 test procedures.
Defined acceptable methods of spark arrester identification	Previous revision did not outline specific acceptable methods for identifying spark arresters in an indelible manner.
Added standards for multiposition small engine (MSE) spark arresters	MSE spark arrester standards differ from those for medium and large-size engines and need to be mentioned separately.
Defined substantiation/procedures for waiving of physical test	Some spark arresters which are similar to previously qualified products may be approved for a waiver from physical testing. The substantiation for the waiver was not previously outlined.
Defined equipment which may exempt an engine from requiring a separate spark arrester	Some engines are equipped with special components which effectively trap debris and do not require unique spark arresters. These exemptions were previously not outlined.

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1. SCOPE.

1.1. Purpose and Applicability. This standard establishes the minimum performance and maintenance requirements of spark arresters for single and multiposition small internal combustion engines used in proximity to grass, brush, timber, and similar cellulose materials. This standard provides methods for arrester performance evaluation, size selection, and determination of application position.

Federal, State, and local laws govern when and where the use of spark arresters is required. During periods of very high or extreme fire danger, arresters meeting this standard may not give complete protection against exhaust spark fires. Additional measures, including complete shutdown of operations, may be required during such periods.

2. APPLICABLE DOCUMENTS.

2.1. Non-Government Publications. Unless otherwise specified, the issues of these documents are those in effect on the date of testing:

Society of Automotive Engineers (SAE)

Surface Vehicle Recommended Practice J350 - Spark Arrester Test Procedure for Medium Size Engines

Surface Vehicle Recommended Practice J335 –Multiposition Small Engine Exhaust System Fire Ignition Suppression

Copies of SAE Standard and Recommended Practice are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

3. INTERPRETATION AND DEFINITIONS.

3.1. Interpretation. To carry out the provisions of this document, the word shall is to be understood as mandatory.

3.2. Definitions.

Application engine: The engine for which the spark arrester is designed. If the spark arrester is to be used on multiple engines, the application engine is the one with the highest design horsepower.

Arresting effectiveness: For centrifugal type spark arresters, the ratio of carbon test material larger than 0.023 inch trapped by the spark arrester to the total carbon test material introduced at the arrester inlet, expressed as a percentage.

Arrester clean-out effectiveness: For centrifugal type spark arresters, the ratio of carbon test material removed during cleanout to the total carbon test material introduced at the arrester inlet, expressed as a percentage.

Accredited laboratory: A laboratory which is has been approved by the USDA Forest Service to test spark arresters and report test results per the appropriate test specification. A list of accredited laboratories is provided in appendix A.

Centrifugal type spark arrester: A type of spark arrester that uses baffles, traps, and/or vanes to remove debris from exhaust flow.

Durable label: A label which has a life expectancy equivalent to that of its substrate. A durable label must be capable of withstanding expected environmental and operating conditions without deterioration.

Emissions durability period (EDP): See “useful life.”

Endurance test: For screen type spark arresters which are installed on single position engines of 50 horsepower (37.3 kW) or greater, a test which demonstrates the candidate spark arrester can endure 100 hours of operation when installed on an appropriately sized engine running at specified operating conditions.

Exhaust system: For screen type spark arresters which are installed on single position engines of 50 horsepower (37.3 kW) or greater, a test which demonstrates the candidate spark arrester can endure 100 hours of operation when installed on an appropriately sized engine running at specified operating conditions.

Multiposition small engine (MSE): A small, portable internal combustion engine operable in more than one orientation. Examples include chain saws, weed trimmers, and brush cutters.

MSE endurance test: For multiposition small engines with nonservicable exhaust systems, a test which demonstrates the candidate spark arrester can withstand the useful life of the engine.

Screen effective area: The total area of screen through which exhaust gases pass (for Screen type spark arresters only). The effective area is smaller than the physical screen area due to screen geometry and obstructions created during fabrication (straps, welds, etc.).

Screen type spark arrester: A type of spark arrester which uses a screen mesh to trap exhaust debris.

Single position engine: An engine designed to be operated in a single orientation.

Spark arrester: Any device which limits or prevents the discharge of debris from the exhaust system of a combustion engine.

Useful life: The average amount of time that the spark arrester exhaust system is estimated to function when installed new.

4. PERFORMANCE REQUIREMENTS.

4.1. Centrifugal Type Spark Arresters.

4.1.1. Test Requirements. Centrifugal spark arresters shall be tested by an accredited laboratory per the requirements of SAE J350. All required test data specified herein must be obtained using the methods described in the test specification.

4.1.2. Arresting Effectiveness. Arresting effectiveness shall be, at minimum, 80 percent at all test points.

4.1.3. Mounting and Installation. The spark arrester shall be mounted in a manner which requires 100 percent of the exhaust gas to pass through the arrester. The spark arrester may not be mounted at an angle of more than 45 degrees from the orientation used during qualification testing. If the spark arrester can be mounted in more than one orientation, the inlet must be clearly identified to prevent improper installation.

4.1.4. Cleanout and Maintenance. The spark arrester shall have provisions for disposal of accumulated particles without the removal of the clamping or mounting devices from the stack, pipe, or manifold assembly. Removable items (other than fasteners) shall be indexed to one position to prevent improper assembly. A written procedure, which clearly describes the cleanout and maintenance procedure shall be provided.

4.1.5. Marking and Identification. The spark arrester shall be permanently identified with the spark arrester model designation and the manufacturer's name or trademark. The markings shall be clearly imprinted in 1/8 inch (3.2 mm) or larger type and be readily visible without removal of the arrester from the engine. Acceptable methods of identification are metal stamping, etching, dot peening, or durable labels.

4.2. Screen Type Spark Arresters (Single Position Engines).

4.2.1. Test Requirements. Screen type spark arresters shall be tested by an accredited laboratory per the requirements of SAE J350. All required test data specified herein must be obtained using the methods described in the test specification.

4.2.2. Screen Geometry. Screen type arresters shall have no screen or housing openings greater than 0.023 inch (0.58 mm). The total area of all screen openings shall not be less than twice the exhaust port area measured at the smallest restriction between the exhaust manifold and spark arrester. For a system with multiple exhaust ports, each exhaust port area (at the smallest restriction) will be added to obtain the total exhaust port area.

4.2.3. Screen Material. Screen material shall be resistant to the high temperatures and corrosive materials present in internal combustion engine exhaust flow.

4.2.4. Endurance Test. Screen type spark arresters with an application engine of 50 horsepower (37.3 kW) or greater shall be tested for 100 hours as outlined in SAE J350.

4.2.5. Mounting and Installation. The spark arrester shall be mounted in a manner which requires 100 percent of the exhaust gas to pass through the arrester. If the spark arrester can be mounted in more than one orientation, the inlet must be clearly identified to prevent improper installation.

4.2.6. Cleanout and Maintenance. The spark arrester shall be easily removable with the use of simple handtools. Welds, rivets, or permanent fasteners are not acceptable. Removable items (other than fasteners) shall be indexed to one position to prevent improper assembly. A written procedure, which clearly describes the cleanout and maintenance procedure shall be provided.

4.2.7. Marking and Identification. The spark arrester shall be permanently identified with the spark arrester model designation, the manufacturer's name or trademark, and the words "SCREEN TYPE." The markings shall be clearly imprinted in 1/8 inch (3.2 mm) or larger type and be readily visible without removal of the arrester from the engine. Acceptable methods of identification are metal stamping, etching, dot peening, or durable labels.

4.3. Multiposition Small Engines (MSE).

4.3.1. Test Requirements. Multiposition small engine spark arresters shall be tested by an accredited laboratory per the requirements of SAE J335. All required test data specified herein must be obtained using the methods described in the test specification.

4.3.2. Arresting Effectiveness. The spark arrester used with the engine exhaust system shall be designed to retain or destroy 90 percent or more of the carbon particles having a major diameter greater than 0.023 inch (0.584 mm).

4.3.3. Screen Geometry. Spark arresting screens shall have no screen or housing openings greater than 0.023 inch (0.58 mm).

4.3.4. Screen Material. Screen material shall be resistant to the high temperatures and corrosive materials present in internal combustion engine exhaust flow.

4.3.5. Debris Accumulation.

4.3.5.1. External pockets. The exhaust system shall be designed so that there are no external pockets in area surrounding the exhaust system where flammable material could accumulate.

4.3.5.2. Internal pockets. An area on the outer surface area of the exhaust system forming an internal pocket shall be either closed or the surface temperature inside the internal pocket shall not exceed 550 °F (288 °C). This applies only to front mounted chain saw exhaust systems.

4.3.6. Exposed Surface Temperature. Exposed exhaust surface temperatures shall not exceed 550 °F (288 °C).

4.3.7. Exhaust Gas Temperature. Exhaust gas temperature shall not exceed 475 °F (246 °C).

4.3.8. Cleanout, Maintenance, and Endurance Testing.

4.3.8.1. Non-Sealed Exhaust Systems. Exhaust systems shall provide for the easy removal of the spark arrester screen for inspection, cleaning, or replacement without major disassembly of the power head or removal of the exhaust system from the engine.

4.3.8.2. Sealed Exhaust Systems. Spark arrester screens installed on sealed, nonserviceable exhaust systems shall have a service life greater than or equal to the manufacturer's defined useful life, when installed and tested in accordance with the procedures outlined in SAE J335. Spark arrester screens meeting these requirements need not be removable.

4.3.9. Marking and Identification. The power unit shall be identified by the manufacturer name or trademark and model number. The exhaust system shall be identified by a unique model ID. Due to size restrictions, a partial marking may be used, provided it uniquely identifies the exhaust system. Acceptable methods of identification are metal stamping, etching, dot peening, or durable labels.

The exhaust system shall be identified by the manufacturer name or trademark and model number. Due to space limitations in these exhaust systems, partial marking is acceptable provided the marking uniquely identifies the unit.

4.4. Waiver of Physical Testing. Spark arresters, which are of similar design to products already qualified to this specification, may be waived from physical testing, provided only minor changes exist between the candidate spark arrester and the previously qualified unit. Examples of minor changes include, but are not limited to, the following:

1. Changes in manufacturer or model name.
2. Changes to mounting brackets or hardware.
3. Changes to the exhaust system, which do not affect spark arresting capabilities.

Waivers of physical testing shall be at the discretion of the USDA Forest Service, San Dimas Technology and Development Center.

4.5. Exemptions. Engines possessing the special equipment specified below have been demonstrated to present a minimal risk of exhaust-spark fires and are exempt from the requirements of this standard.

4.5.1. Turbochargers. Turbocharged engines do not require a spark arrester, provided 100 percent of exhaust gases flow through the turbine wheel and the turbocharger does not have a wastegate.

4.5.2. Diesel Particulate Filters. Engines using a diesel particulate filter (DPF) do not require a spark arrester, provided the following requirements are met:

1. 100% of exhaust gases flow through the DPF.
2. The equipment provides the operator with a visual or audible warning (i.e. dashboard light, message center, or alarm) when the filter requires regeneration, manual cleaning, or replacement.

5. SPARK ARRESTER SELECTION AND INSTALLATION. Spark arresters being used on single position engines other than the application engine shall conform to the requirements specified below. Spark arrester applications not meeting these requirements must undergo qualification testing.

5.1. Engine Performance Requirements. The spark arrester selected shall be rated at an exhaust flow rate greater than or equal to that at which it is rated. The exhaust flow rate shall be determined using the manufacturer's recommended maximum speed and power for intermittent operation or maximum governed speed. Tables for determining flow rates of internal combustion engines are provided in appendix B.

5.2. Exhaust System Integration.

5.2.1. Screen Type Spark Arresters (Single Position Engines). A screen type spark arrester may only be used on the exhaust system for which it was qualified. The same exhaust system may be used on multiple engines, provided the engine's exhaust flow rate does not exceed the qualified flow rate for the system.

APPENDIX A—ACCREDITED LABORATORIES

The following laboratories have been accredited by the USDA Forest Service, San Dimas Technology and Development Center for the testing of spark arrester exhaust systems. Only the laboratories listed below may be used for qualification testing to this standard.

Test Specification	Accredited Laboratory*	Contact Information
SAE J350 (Spark Arresters for Medium Sized Engines)	USDA Forest Service San Dimas Technology and Development Center	Email mailroom_wo_sdtc@fs.fed.us Phone (909) 599-1267 Address 444 E. Bonita Ave San Dimas, CA 91773
SAE J335 (Multiposition Small Engine Exhaust System Fire Ignition Suppression)	Underwriters Laboratories (UL)	Email cec.us@us.ul.com Address 12 Laboratory Drive P.O. Box 13995 Research Triangle Park, NC 27709 USA
	DLG e.V	Email info@dlg.org Address Max-Eyth-Weg 1, D-64823 Groß-Umstadt, Germany
	CSA International	Email client.services@csa.ca Address 178 Rexdale Blvd. Toronto, Ontario Canada M9W 1R3

**Note: The USDA Forest Service San Dimas Technology and Development Center retains final authority over all qualifications, regardless of testing agency*

APPENDIX B – FLOW RATE CALCULATION FOR INTERNAL COMBUSTION ENGINES

The equation provided below is to assist in the determination of engine exhaust flow rate.

$$Q(CFM) = \eta \frac{2 \times D \times RPM}{S \times 1728}$$

where

D = Engine displacement (in³)

RPM = Engine speed (revolutions per minute)

S = Number of strokes per cycle (2 or 4)

η = Volumetric efficiency

Typical values for volumetric efficiency are as follows:

Engine type	η (Volumetric efficiency)
2 or 4 cycle gasoline (naturally aspirated)	0.8
2 or 4 cycle diesel (naturally aspirated)	0.9
Turbocharged or supercharged engines	3.0

**United States Department of Agriculture, Forest Service
Standardization Document Improvement Proposal**

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Standard Number and Title: 5100-1d, "Spark Arresters For Internal Combustion Engines"

Submitter Information

Name of Organization	Type of Organization
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Comments and Suggestions

<i>Section Number</i>	<i>Current Wording</i>	<i>Suggested Change</i>	<i>Reason for Change</i>

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