



SURFACE VEHICLE RECOMMENDED PRACTICE

J312™

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(R) Automotive Gasolines

RATIONALE

SAE J312 is past due for its required Five-Year Review (due in 2015). A review of the recommended practice identified several changes required to bring the practice up to date.

FOREWORD

Automotive gasolines are used to fuel internal combustion spark-ignition engines. While automotive gasolines discussed herein are used primarily in passenger car and highway truck service, they are also used extensively in off-highway utility vehicles and farm machinery, two-stroke and four-stroke cycle marine engines, and other spark-ignition engines employed in a variety of different service applications.

Gasolines are essentially blends of numerous hydrocarbons derived from petroleum. To produce gasoline, refiners initially use fractional distillation of the crude oil to segregate those hydrocarbons in the gasoline boiling range, with finished gasolines encompassing a boiling range of about 30 to 225 °C (86 to 437 °F). A number of processes can then be used to:

- Increase the yield of gasoline from a barrel of crude oil by converting larger-molecule (higher-boiling) and smaller-molecule (lower-boiling) hydrocarbons to hydrocarbons in the gasoline boiling range; or
- Convert low-octane number hydrocarbons to high-octane number hydrocarbons.

The primary processes used by today's refiners are:

- Catalytic cracking, which converts higher-boiling hydrocarbons into hydrocarbons in the gasoline boiling range.
- Reforming, which converts low-octane number hydrocarbons to higher-octane number hydrocarbons.
- Alkylation, which converts gaseous hydrocarbons to high-octane number liquid hydrocarbons.
- Isomerization, which upgrades the octane quality of light straight-run gasoline by converting straight-chain paraffins to their branched-chain isomers.
- Hydrocracking, in which cracking occurs in the presence of both hydrogen and a catalyst, to produce a less olefinic gasoline component.

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Reforming was increasingly used during the 1970s and 1980s to replace the octane numbers lost by the requirement for unleaded gasoline in modern automobiles and the resulting reduction and eventual elimination of lead antiknock usage. Because of environmental restrictions on the aromatic content of gasoline (under the Environmental Protection Agency's Complex Model for reformulated gasoline), alkylation and isomerization are becoming more important. Ethanol is also now contributing significant octane number benefits.

Automotive gasolines (also called motor gasoline) can be gasoline or blends of gasoline and oxygenates, such as ethanol. In 2017, about 95% of automotive gasoline contained ethanol. The use of ethanol as a blending component is discussed in Section 9.

Automotive gasolines are blended to satisfy diverse automobile requirements. Antiknock rating, volatility, and other properties are balanced to provide satisfactory vehicle performance. Additives are used to provide or enhance specific performance features and have become increasingly important in late-model vehicles. This SAE Recommended Practice summarizes the significance of the more important physical and chemical characteristics of automotive gasolines, and describes pertinent test methods for defining or evaluating these properties. Information on properties of automotive gasolines currently marketed in service stations throughout the United States can be found in semiannual reports; for example, the Alliance of Automobile Manufacturers conducts semiannual surveys of gasoline quality in the U.S., and, to a limited extent, in Canada and Mexico. A number of proprietary surveys are also conducted.

1. SCOPE

This SAE Recommended Practice summarizes the composition of modern automotive gasolines, the significance of their physical and chemical characteristics, and the pertinent test methods for defining or evaluating these properties.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Telephone 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1082	Fuel Economy Measurement - Road Test Procedure
SAE J1297	Alternative Automotive Fuels
SAE J1349	Engine Power Test Code - Spark Ignition and Compression Ignition - As Installed Net Power Rating
SAE J1498	Heating Value of Fuels
SAE J1681	Gasoline, Alcohol, and Diesel Fuel Surrogates for Materials Testing
SAE J1829	Stoichiometric Air-Fuel Ratios of Automotive Fuels

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D56	Standard Test Method for Flash Point by Tag Closed Cup Tester
ASTM D86	Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure
ASTM D130	Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
ASTM D381	Standard Test Method for Gum Content in Fuels by Jet Evaporation
ASTM D445	Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
ASTM D471	Standard Test Method for Rubber Property - Effect of Liquids
ASTM D525	Standard Test Method for Oxidation Stability of Gasoline (Induction Period Method)
ASTM D665	Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water
ASTM D1250	Standard Guide for Use of the Petroleum Measurement Tables
ASTM D1266	Standard Test Method for Sulfur in Petroleum Products (Lamp Method)
ASTM D1298	Standard Test Method for Density, Relative Density (Specific Gravity) or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
ASTM D1319	Standard Test Method for Hydrocarbon Types in Petroleum Products by Fluorescent Indicator Adsorption
ASTM D2622	Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence
ASTM D2699	Standard Test Method for Research Octane Number of Spark-Ignition Engine Fuel
ASTM D2700	Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel
ASTM D2885	Standard Test Method for Determination of Octane Number of Spark-Ignition Engine Fuels by On-Line Direct Comparison Technique
ASTM D3120	Standard Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
ASTM D3231	Standard Test Method for Phosphorus in Gasoline
ASTM D3237	Standard Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy
ASTM D3338	Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
ASTM D3828	Standard Test Methods for Flash Point by Small Scale Closed Cup Tester
ASTM D4052	Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
ASTM D4806	Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel
ASTM D4809	Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)

ASTM D4814	Standard Specification for Automotive Spark-Ignition Engine Fuel
ASTM D4815	Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C ₁ to C ₄ Alcohols in Gasoline by Gas Chromatography
ASTM D4953	Standard Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
ASTM D5059	Standard Test Methods for Lead in Gasoline by X-Ray Spectroscopy
ASTM D5188	Standard Test Method for Vapor-Liquid Ratio Temperature Determination of Fuels (Evacuated Chamber Method)
ASTM D5190	Standard Test Method for Vapor Pressure of Petroleum Products (Automatic Method)
ASTM D5191	Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)
ASTM D5453	Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
ASTM D5482	Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method - Atmospheric)
ASTM D5500	Standard Test Method for Vehicle Evaluation of Unleaded Automotive Spark-Ignition Engine Fuel for Intake Valve Deposit Formation
ASTM D5598	Standard Test Method for Evaluating Unleaded Automotive Spark-Ignition Engine Fuel for Electronic Port Fuel Injector Fouling
ASTM D5599	Standard Test Method for Determination of Oxygenates in Gasoline by Gas Chromatography and Oxygen Selective Flame Ionization Detection
ASTM D5797	Standard Specification for Fuel Methanol (M70-M85) for Automotive Spark-Ignition Engines
ASTM D5798	Standard Specification for Fuel Ethanol (Ed70-Ed85) for Automotive Spark-Ignition Engines
ASTM D5845	Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, Methanol, Ethanol and Tert-Butanol in Gasoline by Infrared Spectroscopy
ASTM D6378	Standard Test Method for Determination of Vapor Pressure (VP _x) of Petroleum Products, Hydrocarbons, and Hydrocarbon-Oxygenate Mixtures (Triple Expansion Method)
ASTM D6593	Standard Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation in a Spark-Ignition Internal Combustion Engine Fueled with Gasoline and Operated Under Low-Temperature, Light-Duty Conditions
ASTM D6709	Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence VIII Spark-Ignition Engine (CLR Oil Test Engine)
ASTM D6837	Standard Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIB Spark Ignition Engine
ASTM D6920	Standard Test Method for Total Sulfur in Naphthas, Distillates, Reformulated Gasolines, Diesels, Biodiesels, and Motor Fuels by Oxidative Combustion and Electrochemical Detection
ASTM D6984	Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIF, Spark-Ignition Engine
ASTM D7039	Standard Test Method for Sulfur in Gasoline and Diesel Fuel by Monochromatic Wavelength Dispersive X-Ray Fluorescence Spectrometry

ASTM D7220	Standard Test Method for Sulfur in Automotive, Heating, and Jet Fuels by Monochromatic Energy Dispersive X-Ray Fluorescence Spectrometry
ASTM D7320	Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIG, Spark-Ignition Engine
ASTM D7345	Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)
ASTM D7667	Standard Test Method for Determination of Corrosiveness to Silver by Automotive Spark-Ignition Engine Fuel (Thin Silver Strip Method)
ASTM D7671	Standard Test Method for Corrosiveness to Silver by Automotive Spark-Ignition Engine Fuel (Silver Strip Method)
ASTM D7757	Standard Test Method for Silicon in Gasoline and Related Products by Monochromatic Wavelength Dispersive X-Ray Fluorescence Spectrometry
ASTM D8076	Standard Specification for 100 Research Octane Number Test Fuel for Automotive Spark-Ignition Engines
ASTM E659	Standard Test Method for Autoignition Temperature of Liquid Chemicals

2.1.3 Other Standards

CAN/CGSB-3.5	Unleaded Automotive Gasoline
CAN/CGSB-3.511	Oxygenated Unleaded Automotive Gasoline Containing Ethanol
Commercial Item Description A-A-52530	Gasohol, Automotive, Unleaded
EN 228	Automotive Fuels - Unleaded Petrol - Requirements and Test Methods
JIS K 2202	Motor Gasoline
NACE Standard TM0172-2001	Test Method for Determining Corrosive Properties of Cargoes in Petroleum Product Pipelines

2.1.4 Other Publications

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CRC Publications are available from Coordinating Research Council, Inc., 3650 Mansell Road, Suite 140, Alpharetta, GA 30022, Telephone 678-795-0506, www.crao.com.

U.S. Government specification A-A-52530 for Gasohol is available at www.assistdocs.com.

Renewable Fuels Association publications are available at www.ethanolrfa.org.

3. ANTIKNOCK QUALITY⁽¹⁻⁸⁾

The antiknock quality of an automotive gasoline is of prime importance for optimal engine performance. If fuel antiknock quality is too low compared to the engine octane number requirement, engine spark knock can occur. Engine spark knock occurs when the air-fuel mixture end gases in the combustion chamber autoignite after the spark plug fires. It results in a high-pitched metallic rapping or pinging noise that can be audibly annoying to the driver. In addition, severe and prolonged knock can cause burning of piston crowns, increased engine wear, and other engine damage. Modern automotive engines have knock sensors and electronic engine controls which generally prevent audible knock and engine damage by retarding spark (and in some cases by also reducing turbocharger boost pressure or enriching the air-fuel ratio). Spark retard prevents knock but it decreases torque and power, degrades efficiency, and increases exhaust temperature. The potential durability, power, fuel economy, and emissions of a given engine is realized only when the gasoline antiknock quality is adequate and closely matches the engine's octane number requirement. Conversely, fuel economy and power can suffer if fuels of adequate antiknock quality are not used. There is generally no advantage in using a gasoline having antiknock quality higher than the engine requires. However, engines with knock sensors can show improved performance as the antiknock quality of the fuel is increased up to the maximum engine requirement. Section 11 contains additional details on knock sensors and other engine design factors affecting octane number requirement.

Engine spark knock depends on complex physical and chemical phenomena highly interrelated with engine design, engine operating conditions, and atmospheric conditions. It is impossible to completely characterize the antiknock performance of gasoline with a single measurement. The antiknock performance of a gasoline is intimately related to the engine in which it is used and to the engine and transmission operating conditions. Furthermore, this relationship varies from one engine design and one engine controls calibration to another and can be significantly different among engines of the same design due to normal production variations.

In addition to spark knock, there are other abnormal combustion phenomena that can occur in a spark-ignition engine. Surface ignition involves the ignition of the air-fuel mixture by a hot spot rather than by the spark plug. Potential ignition sources include glowing combustion chamber deposits, sharp edges or burrs in the combustion chamber, or an overheated spark plug electrode. The hot spot ignites the air-fuel mixture before the spark plug initiates normal combustion. Surface ignition before the spark is called preignition. When preignition occurs, control of ignition timing is lost and the upward movement of the piston is opposed by the high pressure generated by the early combustion. This results in roughness, power loss, and severe localized heating of the piston crown. If it is prolonged, the localized heating can burn a hole in the piston. Preignition does not respond to octane number like spark knock does.

The antiknock quality of commercially sold gasoline is measured by two ASTM test methods using single-cylinder laboratory engines: ASTM D2699 and ASTM D2700.

Both of these test methods employ nearly identical variable-compression-ratio engines. The motor method (ASTM D2700) operates at a higher speed and higher inlet mixture temperature than does the research method (ASTM D2699). They relate the knocking characteristics of a given test gasoline to primary reference fuels (PRF), which are blends of two pure hydrocarbons: isooctane (2,2,4-trimethylpentane) and n-heptane. By definition, for both test methods, the octane number of isooctane is 100 and the octane number of n-heptane is zero. At octane levels below 100, the octane number of the PRF is the percentage by volume of isooctane in a blend with n-heptane. An unknown gasoline is given an octane number equal to the PRF that knocks in the test engine with the same intensity at the same compression ratio. The octane number of a gasoline greater than 100 can be measured by comparing it to PRFs greater than 100 which are made by adding tetraethyllead to isooctane. The number of milliliters of tetraethyllead in isooctane is converted to octane numbers greater than 100 by use of tables published by ASTM. The final test results are reported as RON for the Research Octane Number and MON for the Motor Octane Number.