

## Lubricants for Two-Stroke-Cycle Gasoline Engines

1. **Scope**—The information in this SAE Recommended Practice has been compiled by Technical Committee 1 (Engine Lubricants) of the SAE Fuels and Lubricants Division. The intent is to provide those concerned with the design and maintenance of two-stroke-cycle engines with a better understanding of the properties of two-stroke-cycle lubricants. Reference is also made to test procedures which may be used to measure the chemical and physical characteristics of these lubricants.

### 2. References

2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1536—Two-Stroke-Cycle Engine Oil Fluidity/Miscibility Classification

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 93—Test Methods for Flash Point by Pensky-Martens Closed Tester

ASTM D 874—Test Method for Sulfated Ash from Lubricating Oils and Additives

ASTM D 3607—Method for Removing Volatile Contaminants from Used Engine Oils by Stripping

ASTMD4682-87—Specification for Miscibility with Gasoline and the Fluidity of Two-Stroke-Cycle Gasoline Engine Lubricants

3. **Lubricant Classification**—At the present time, two-stroke-cycle engine and lubricant manufacturers use a variety of engine and bench tests to define lubricant performance. For example, for several years the National Marine Manufacturers Association (NMMA) has been approving oils for water-cooled, two-stroke-cycle outboard engines. Products with this approval bear a NMMA TC-W3® or TC-W II® logo.

The value of a universal classification for all two-stroke-cycle lubricants is widely accepted. SAE, JASO, NMMA, ASTM, and CEC are currently developing such a system, encompassing several categories. It will aid in the correct labeling and application of these oils and will classify them according to their relative performance, but not necessarily their suitability in a given engine or application.

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4. **Engine Applications**—Two-stroke-cycle engines are used in many applications with a broad range of specific power outputs. Water-cooled outboard engines with displacements to 4000 cc are not uncommon. At the other end of the scale are air-cooled engines for power tools, with displacements of 30 cc or less. In between are engines with various displacements and specific outputs. Typically, they are used to power motorbikes, lawn mowers, motorcycles, small tractors, chainsaws and other hand-held equipment, portable generators or pumps, snowmobiles, personal watercraft, etc.

5. **Lubrication Systems**—Two approaches to two-stroke-cycle engine lubrication are common:

- a. Pre-mixing, in which the lubricant is added to the fuel either in the fuel tank or before it is put in the fuel tank
- b. Injection, in which the lubricant is metered directly into the intake manifold or other points using a pump that is controlled by engine speed and/or throttle setting or where the lubricant is metered into the gasoline between the fuel tank and the engine

Use of oil injection systems is increasing. In addition to being more convenient, the injection system optimizes lubricant delivery rates over varying power and speed ranges.

6. **Fuel:Oil Ratios**—The ratio of fuel to oil depends on the engine, the application, and the lubricant. A fuel-to-oil ratio of 50:1 is often specified by both engine manufacturers and lubricant marketers for oils such as those used in large outboard engines. However, higher ratios, for example, 100:1, are sometimes recommended. Ratios as low as 16:1 are sometimes specified for use in air-cooled engines.

Variable ratios are characteristic of lube-injection systems. In one lube-injected snowmobile, for example, the ratio varies from 100:1 at idle to 24:1 at wide open throttle (WOT).

7. **Lubricant Role**—Two-stroke-cycle gasoline engines typically utilize “once through” lubrication. In any application, the lubricant is expected to protect the engine from wear, scuffing, ring sticking, piston deposits, and rust. It must do so without causing excessive plug fouling, pre-ignition, detonation, or exhaust system blockage. If the engine is lube-injected, the lubricant should continue to flow from the reservoir to the injection pump at the lowest ambient temperature expected in the application for which the lubricant is intended.

8. **Oil Composition**—With the wide variety of two-stroke-cycle engines and uses, one lubricant composition may not be optimum for all applications. However, two-stroke-cycle engine lubricants, like other lubricant classes, do have features in common. The base oils are most often petroleum derived but can be synthetic or part synthetic containing base fluid components such as ester and polyisobutene. Frequently, a portion of the base oil is a high viscosity component such as bright stock. Most oils contain an additive package to improve engine cleanliness. Many contain a hydrocarbon diluent to improve the miscibility (rate of mixing) with gasoline and the fluidity (flow) at low ambient temperatures. Some two-stroke-cycle engine lubricants also contain a pour depressant.

For some applications, for example, large outboard engines, where WOT operation for extended periods is common practice, the cleanliness additives must be essentially ashless to avoid pre-ignition and detonation. However, most lubricants, especially those designed for air-cooled engines, contain ash-forming components to control ring zone deposits at high-operating temperatures. Some modern air-cooled engines perform best with oils containing a mixture of ashless and ash-forming components.

## 9. *Physical and Chemical Properties*

**9.1 Fluidity and Miscibility**—The rheological requirements for two-stroke-cycle engine lubricants do not include viscosity exclusively. Lubricants must also have the ability to mix into gasoline and/or flow at the prevailing ambient temperature.

SAE J1536 and the supporting ASTM standard specification D 4682, describe four grades of two-stroke-cycle engine lubricants according to rheological properties.

**9.2 Rust**—The ability of the oil to prevent internal engine corrosion during shut-down is critical. The NMMA TC-W II<sup>®</sup> or TC-W3<sup>®</sup> standards provide a laboratory test procedure whereby the rust inhibiting properties of an oil in the presence of a brine solution can be established.

**9.3 Stability and Compatibility**—It is imperative that oils intended for use in lube-injected engines remain homogeneous over a broad range of ambient temperatures for extended periods of time. Otherwise, filter plugging and engine damage due to oil starvation may occur. Therefore, oils should be inspected to ensure that they are free of gel, sediment, particulates, immiscible liquids, etc. The NMMA TC-W3<sup>®</sup> specification requires that products demonstrate compatibility with commonly available two-stroke cycle outboard lubricants.

Lubricants must remain fluid when contaminated with small amounts of water. Lubricants which are individually satisfactory may not be so when mixed with other oils.

**9.4 Pour Point**—Two-stroke-cycle engine lubricants are usually pour depressed to ensure adequate dispensability over extended periods of time at lower ambient temperatures. The degree of pour depression, which varies depending on the intended applications, can be established using method ASTM D 97.

**9.5 Solvent Content**—The solvent content of a two-stroke-cycle engine lubricant can be established by using ASTM D 3607. However, because the solvent levels are considerably higher than the fuel contents of used oils, the stripping time should be extended 6 h.

**9.6 Ash Content**—The amount of ash formed from burning a two-stroke-cycle engine lubricant may be obtained by ASTM D 874. As noted in Section 8, some engines do not perform satisfactorily with ash-forming lubricants, while others benefit from them.

**9.7 Elemental Analysis**—The elemental analysis of lubricants containing ash-forming additives can be established using such techniques as emission spectroscopy, X-ray fluorescence, etc. The level of metal detergents can be determined using one of these methods.

The additive level of ashless two-stroke-cycle oils generally can be determined by an analysis for elemental nitrogen.

**9.8 Flash Point**—The flash point of solvent-diluted two-stroke-cycle engine lubricants can be quite low, for example, in the range of 40 to 65 °C (104 to 149 °F) by ASTM D 93. Such lubricants may be classified as “combustible liquids.” This has obvious safety implications in terms of lubricant manufacturing, storage, packaging, or shipment.

**9.9 Color**—Many two-stroke-cycle engine lubricants are dyed to help establish that the oil has been mixed with gasoline prior to use. The intensity of the color should, therefore, be high enough to ensure a light, but readily visible, color after mixing. Because of the possibility of confusion with transmission fluids, it is recommended that a dye color other than red be used. Blue and green are common.