

**PERSONAL WATERCRAFT FUEL SYSTEMS**

**Foreword**—This Document has not changed other than to put it into the new SAE Technical Standards Board format.

**1. Scope**—This SAE Recommended Practice applies to permanently installed gasoline fuel systems in personal watercraft as defined in 2.2, except fuel systems on outboard engines.

**1.1 Purpose**—This document specifies guidelines for fuel systems of personal watercraft. This document is intended as a guide toward standard practice and is subject to change to keep pace with experience and technical advances.

**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 PUBLICATIONS**—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1527—Marine Fuel Hoses

**2.1.2 ASTM PUBLICATIONS**—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM D 380—Methods of Testing Rubber Hose

ASTM D 413—Test Method for Rubber Property—Adhesion to Flexible Substrate

ASTM D 471—Test Method for Rubber Property—Effect of Liquid

ASTM D 573—Test Method for Rubber: Deterioration in an Air Oven

ASTM D 1149—Test Method for Rubber Deterioration Surface Ozone Cracking in a Chamber

ASTM D 1621—Compressive Strength of Rigid Cellular Plastics

ASTM D 1622—Apparent Density of Rigid Cellular Plastics

**2.1.3 MILITARY PUBLICATIONS**—Available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL P-21929B Plastic Material Cellular Polyurethane, Foam-in-Place, Rigid Two and Four Pounds per Cubic Foot

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### 3. Definitions

- 3.1 Fuel System**—means the entire assembly of the fuel fill, vent, tank and distribution components including pumps, valves, strainers, carburetors, and filters.
- 3.2 Static Floating Position**—means the attitude in which a watercraft floats in calm water, with each fuel tank filled to its rated capacity, but with no person or items of portable equipment on board.
- 3.3 Personal Watercraft**—means a vessel less than 4 m in length, which uses an internal combustion engine powering a water jet pump as its primary source of propulsion, and is designed to be operated by a person or persons sitting, standing, or kneeling on, rather than within, the confines of a hull.

### 4. General

- 4.1** Each fuel system fitting, joint, and connection must be arranged so that it can be reached for inspection, removal, or maintenance without removal of permanent boat structure.
- 4.2** The fuel system shall be designed not to leak liquid fuel into the watercraft when: (a) the watercraft is overturned through 180 degrees of roll in either direction, and (b) the watercraft is overturned through 90 degrees of pitch in either direction.
- 4.3** The fuel system shall be designed not to leak liquid fuel into the watercraft when subjected to 21 kPa (3.0 psi) or 90% design relief pressure of the system, whichever is greater.
- 4.4** The fuel system shall be designed to automatically stop the supply of fuel to the engine when the engine is not running.

### 5. Fuel Tanks

#### 5.1 Fuel Tank Prohibited Materials

- 5.1.1** A fuel tank shall not be constructed of terneplate.
- 5.1.2** Unless it has an inorganic sacrificial galvanic coating on the inside and outside of the tank, a fuel tank shall not be constructed of black iron or steel.
- 5.1.3** A fuel tank encased in cellular plastic or in fiber-reinforced plastic shall not be constructed from a ferrous alloy.

#### 5.2 Cellular Plastic Used to Encase Fuel Tank

- 5.2.1** Cellular plastic used to encase fuel tanks shall not change volume by more than 5% or dissolve after being immersed in any of the following liquids for 24 h at 29 °C (84 °F):
- Reference fuel B of ASTM D 471
  - No. 2 reference oil of ASTM D 471
  - 5% solution of trisodium phosphate in water
- 5.2.2** Cellular plastic used to encase fuel tanks shall not absorb more than 55 g (0.12 lb) of water per 930 cm<sup>2</sup> (1 ft<sup>2</sup>) of cut surface, measured under Military Specification MIL P-21929B.
- 5.2.3** Non-polyurethane cellular plastic used to encase metallic fuel tanks must have a compressive strength of at least 414 kPa (60 lb/in<sup>2</sup>) at 10% deflection measured under ASTM D 1621.

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- 5.2.4 Polyurethane cellular plastic used to encase metallic fuel tanks must have a density of at least  $0.032 \text{ g/cm}^3$  ( $2.0 \text{ lb/ft}^3$ ), measured under ASTM D 1622.
- 5.3 A means shall be provided to check the fuel level or a reserve fuel supply shall be provided.
- 5.4 With the watercraft in its static floating position, a fuel tank when filled shall have an air expansion volume or be equipped with a system that prevents pressure in the tank from exceeding 80% fuel tank design pressure.
- 5.5 Fill and vent openings shall be at or above the liquid level when the tank is filled to capacity in its static floating position.
- 5.6 **Fuel Tank Static Pressure Test**—A representative fuel tank shall not leak if tested using the following procedures.
- 5.6.1 Fill the tank with air or inert gas to 21 kPa (3 psi) or 90% of the design relief pressure, whichever is greater.
- 5.6.2 Examine each tank fitting and seam for leaks using a leak detection method other than the pressure drop method.
- 5.7 **Fuel Tank Shock Test**—A representative fuel tank shall not leak when tested using the following procedure.
- 5.7.1 Confirm that the tank does not leak when pressure tested according to 4.6.
- 5.7.2 If the tank is nonmetallic, precondition the tank by filling it to capacity with gasoline that has at least a 50% aromatic content. Keep the fuel in the tank at  $21 \text{ }^\circ\text{C}$  ( $70 \text{ }^\circ\text{F}$ ) or higher for at least 30 days prior to testing.
- 5.7.3 Mount the empty tank on the platform of an impact test machine in a manner similar to the manner in which the tank is installed in the watercraft.
- 5.7.4 Fill the tank to capacity with water.
- 5.7.5 Apply 1000 cycles of 25G vertical accelerations at a rate of 80 cycles or less per minute. Apply the accelerations within 76 mm (3 in) of the center of the horizontal mounting surface of the tank. The duration of each vertical acceleration pulse measured at the base of the shock envelope must be between 6 and 14 ms.
- 5.7.6 Check the tank for leaks using the procedure specified in 4.6.
6. **Fuel Tank Installations**
- 6.1 Each fuel tank shall not support a deck, bulkhead, or other structural component.
- 6.2 Fuel tanks shall not be integral with the hull or engine.
- 6.3 Each metallic fuel tank as installed shall permit water to drain from the top surface when the watercraft is in its static floating position.
- 6.4 Each fuel tank support, chock, or strap that is not integral with a metallic fuel tank shall be insulated from the tank surface by a material that does not absorb moisture.
- 6.5 Cellular plastic shall not be the sole support for a metallic fuel tank.

## 6.6 Plastic Encased Fuel Tanks

- 6.6.1 Each fuel tank encased in cellular plastic foam or in fiber-reinforced plastic shall have the connection and fittings accessible for inspection and maintenance.
- 6.6.2 If a metallic fuel tank is encased in cellular plastic or in fiber-reinforced plastic, water shall not collect between the plastic and the surface of the tank or be held against the tank by capillary action.
- 6.6.3 If the plastic is bonded to the surface of a metallic fuel tank, the adhesive strength of the metal to the plastic bond shall exceed the cohesive strength of the plastic.

## 7. Fuel Tank Fill System

- 7.1 Each fuel fill opening shall be located so that when the watercraft is in its static floating position, a gasoline overflow of up to 19 L (5 gal) per minute for at least 5 s will not enter the watercraft.
- 7.2 Each hose in the tank fill system shall be secured to a pipe, spud, or hose fitting by a method which prevents leaks and prevents the hose from becoming disconnected.

## 8. Fuel Pumps

- 8.1 Each diaphragm fuel pump shall not leak fuel into the watercraft if the primary diaphragm fails.
- 8.2 Each electrically operated fuel pump shall not operate except when the engine is operating or when the engine is being started.

## 9. Carburetors—Each carburetor shall not leak more than 5 cm<sup>3</sup> of fuel in 30 s when:

- a. The float valve is open (if applicable)
- b. The carburetor is at half throttle and
- c. The engine is cranked without starting or the fuel pump is delivering the maximum pressure specified by its manufacturer (if applicable).

## 10. Fuel Stop Valves—Each electrically operated fuel stop valve in a fuel line between the fuel tank and the engine shall open electrically only when the ignition switch is on.

## 11. Fuel Filters and Strainers—Each fuel filter and strainer must be supported on the engine or boat structure independent from its fuel line connections, unless the fuel filter or strainer is inside a fuel system component.

## 12. Spud, Pipe and Hose Fitting—Except when used for a tank fill line, each spud, pipe, or hose fitting used with hose clamps shall have a bead, a flare, or a series of annular grooves or serrations no less than 0.4 mm (0.015 in) in depth.

## 13. Clips, Straps, and Hose Clamps

- 13.1 Each clip, strap, and hose clamp must be of a corrosion-resistant material and not cut or abrade the fuel line.
- 13.2 Hose clamps, when used, shall be used with hose designed for clamps.
- 13.3 Hose clamps, when used, shall be beyond the bead or flare, or over the serrations of the mating spud, pipe, or hose fitting.

**14. Metallic Fuel Line**

**14.1** Each metallic fuel line connecting the fuel tank with the fuel inlet connection on the engine shall not be made of carbon steel; and except for corrugated flexible fuel line, each metallic fuel line shall have a minimum wall thickness of 0.74 mm (0.029 in).

**14.2** Each metallic fuel line that is mounted to the watercraft structure shall be connected to the engine by a flexible fuel line and shall be attached to the watercraft's structure within 102 mm (4 in) of its connections to a flexible fuel line.

**15. Plugs and Fittings**—A fuel system shall not have a fitting for draining fuel.

**Exception**—A plug used to remove fuel and/or water within the fuel filter or strainer shall have a tapered pipethread or be a screw type fitting with a locking device other than a split lock washer.

**16. Hoses and Connections**

**16.1** Each vent and fuel distribution hose shall meet the requirements of Section 19.

**16.2** Each vent and fuel distribution hose shall be secured by a method which prevents leaks and prevents the hose from becoming disconnected.

**17. Grounding**—Each metallic component of the fuel fill system and fuel tank which is in contact with fuel must be statically grounded so that resistance between the ground and each metallic component of the fuel fill system and the fuel tank is less than 100  $\Omega$ .

**18. Fire Test**—The fuel system in a representative personal watercraft equipped with its complete engine and fuel system shall not leak when tested using the following procedure.

**18.1** Fill the fuel tank to one-fourth total capacity.

**18.2** Close all bilge drains which might permit the fuel to flow out of the engine compartment.

**18.3** Confirm fuel system meets the requirements of 4.3.

**18.4** Pour an amount of heptane over the engine sufficient to burn at least 2.5 min, but no longer than 5 min.

**18.5** Ignite the heptane.

**18.6** Observe burning heptane after ignition.

**18.7** Close engine compartment.

**18.8** Wait 2 min, 30 s.

**18.9** Open engine compartment and extinguish any remaining flame with carbon dioxide (CO<sub>2</sub>).

**18.10** Pressurize the fuel system to 2 kPa (0.25 psi) with air or inert gas and check for leaks.

**19. Fuel Hose Specifications**—The following hose specifications apply to two types of fuel hose for personal watercraft. One type is a reinforced hose with a cover and the other is a hose without a cover.

**19.1 Tensile Strength and Elongation**—Test in accordance with ASTM D 573 procedures for Tensile Strength and Elongation. Specimens shall meet the conditions of Table 1.

TABLE 1—TENSILE STRENGTH AND ELONGATION

Specification	Hose with Cover Tube Material	Hose with Cover Cover Material	Hose without Cover Hose Material
Original Strength	8.0 MPa	7.0 MPa	8.0 MPa
Original Elongation	200% Minimum	200% Minimum	200% Minimum

**19.2 Dry Heat Resistance**—After heat aging per ASTM D 573 for 70 h at  $100\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  ( $212\text{ }^{\circ}\text{F} \pm 4\text{ }^{\circ}\text{F}$ ) specimens taken from the hose shall not have a reduction in tensile strength of more than 20% or a reduction in elongation of more than 50%.

**19.3 Ozone Resistance**—Test procedure, apparatus, and acceptance level shall be in accordance with ASTM D 1149. This test applies to the outer surface of the hose only and cracks in the inner surface or cut edges shall be ignored.

**19.4 Oil Resistance**—After 70 h immersion at  $100\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  ( $212\text{ }^{\circ}\text{F} \pm 4\text{ }^{\circ}\text{F}$ ) in ASTM Oil No. 3 per ASTM D 471, specimens taken from the hose shall meet the conditions of Table 2.

TABLE 2—OIL RESISTANCE

Specification	Hose with Cover Tube Material	Hose with Cover Cover Material	Hose without Cover Hose Material
Reduction in Tensile Strength	Not more than 40%		Not more than 40%
Reduction in Elongation	Not more than 40%		Not more than 40%
Volumetric Change	-5% to +25%	0 to +100%	-5% to +25%

**19.5 Burst Test**—The minimum burst when tested according to ASTM D 380 shall be 294 kPa (42.7 psi).

**19.6 Vacuum Collapse Test**—A 1 m (3.28 ft) length of hose shall be held in a straight line, and no diameter shall decrease by more than 20% during application of a vacuum of 67.6 kPa (20 in Hg) for a minimum of 15 s and not more than 60 s. The vacuum collapse test on preformed parts should be performed on the finished part.

**19.7 Cold Flexibility**—The test specimen shall be conditioned per ASTM D 380 at  $-20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  ( $-4\text{ }^{\circ}\text{F} \pm 4\text{ }^{\circ}\text{F}$ ) for 5 h and then flex in the cold chamber through 180 degree from the centerline to a diameter of ten times the maximum OD of the hose. The flexing shall take place within 4 s and the hose must not fracture or show any cracks or breaks. Proof pressure of 0.68 MPa (99 psi) may be applied to determine hose damage.

**19.8 Adhesion Test (Reinforced Hose with Cover)**—The minimum load required to separate a 25.4 mm (1 in) width of tube and cover at  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  ( $73\text{ }^{\circ}\text{F} \pm 4\text{ }^{\circ}\text{F}$ ) per ASTM D 413 shall be 27 N (6 lb).

### 19.9 Fuel Resistance

19.9.1 After 48 h immersion at  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  ( $73\text{ }^{\circ}\text{F} \pm 4\text{ }^{\circ}\text{F}$ ) per ASTM D 471 in ASTM Fuel C, physical values of specimens taken from the hose shall not exceed the change in values listed in Table 3.

TABLE 3—FUEL RESISTANCE

Change	Values
Tensile Change	-45%
Elongation Change	-45%
Volume Change	0 to +50%

19.9.2 Permeation shall be tested in accordance with SAE J1527 and shall not exceed 300 g/m<sup>2</sup>/24 h.

PREPARED BY THE SAE PERSONAL WATERCRAFT SUBCOMMITTEE  
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