Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment

Final Regulatory Impact Analysis

Chapter 1
Industry Characterization

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

United States
Environmental Protection
Agency

EPA420-R-08-014
September 2008

CHAPTER 1: Industry Characterization

CHAPTER 1: Industry Characterization

The information contained in this chapter on the Small SI engine and Marine SI engine industries was assembled by RTI International, a Health, Social and Economics Research firm in cooperation with EPA. RTI prepared one report each on the Small SI and Marine SI industries, "Industry Profile for Small Nonroad Spark Ignition Engines and Equipment"[1] and "Industry Profile for Marine SI Industry"[2] report. The following sections provide a brief report overview. The reader is encouraged to refer to the reports for greater detail. In addition, this chapter includes an overview of production practices for fuel system component manufacturers. Chapter 10 provides more information on businesses that would be affected by new standards.

1.1 Manufacturers of Small SI Engines

The nonroad spark-ignition (SI) industry includes a wide variety of handheld and nonhandheld equipment. Nonhandheld equipment is powered mainly by four-stroke gasoline engines; handheld equipment is powered mainly by two-stroke gasoline engines. Comprising much of what the general public considers "lawn and garden (L&G) equipment," this industry also produces significant numbers of generators, compressors, and construction and maintenance equipment. The industry often refers to itself as the "outdoor power equipment" industry.

The industry profile report prepared by RTI for Small SI provides background information on the engines and equipment that make up the small nonroad SI industry, defined as those products rated less than or equal to 19 kilowatt (kW) (roughly equivalent to 25 horsepower [hp]). The profile describes markets for engines and equipment, and discusses their use in both consumer and commercial applications. In each market, producers and consumers are described, along with product attributes and the effect of those attributes on production cost and demand. The market analysis emphasizes assessing suppliers' cost of production and industry structure, along with demanders' price responsiveness and consumption alternatives.

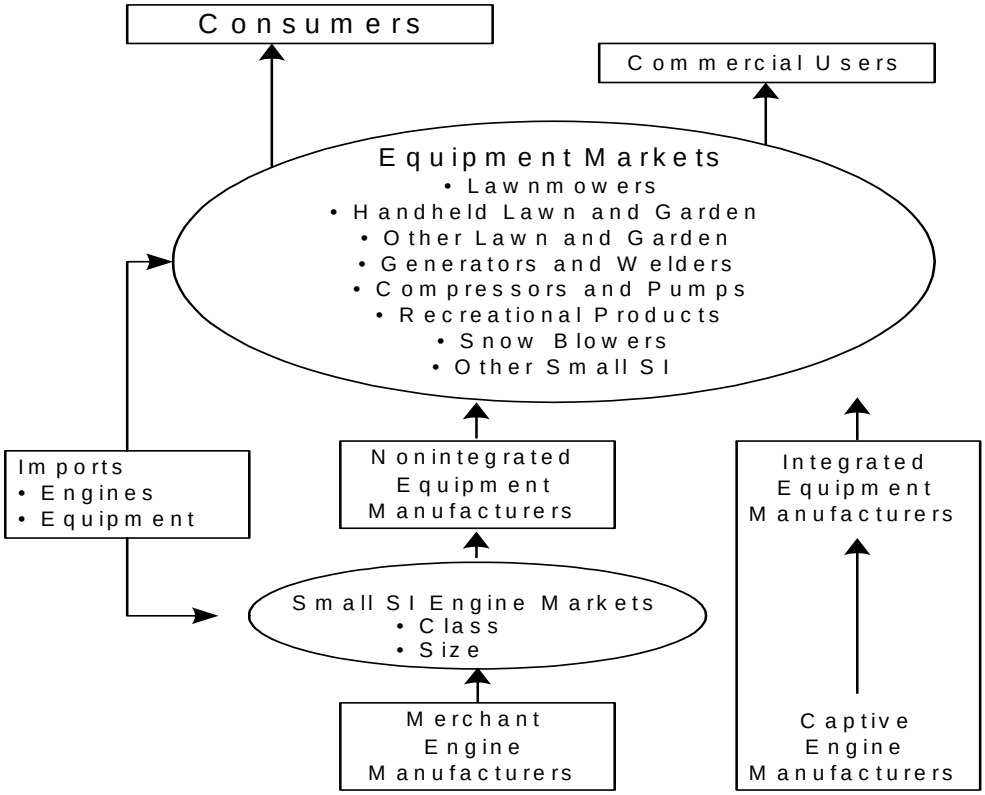
The variety of products in this industry is usefully partitioned by both application categories and engine type. Figure 1-1 illustrates the links between the market segments of the Small SI engine supply chain included in the profile, from engine manufacturing and sale to equipment production, and on to purchase by consumers and commercial customers. Although more than 98 percent of total unit sales in the L&G equipment sector go to households, other sectors' sales are dominated by commercial equipment. Because of the significantly higher prices of commercial units, commercial sales represent a considerable share of the total value of production.

It should be noted that there is a fair amount of vertical integration in the handheld industry, with the same parent firm making both engines and the equipment in which those engines are used. Handheld equipment includes string trimmers, leaf blowers, and chainsaws. This situation is known as "captive" engine production; data on internal consumption of engines and transfer prices are typically not available outside the firm. The makers of non-handheld

engines typically sell their engines to independent equipment manufacturers in a merchant engine market, where prices and quantities exchanged can be directly observed.

The industry profile report prepared by RTI for Small SI presents information on product characteristics, supply-side considerations, consumer demand, and market structure for small nonroad SI engines. The report also includes similar types of information on equipment markets, broken down by application category. Considerations related to consumer and commercial markets are included in the report.

Figure 1-1: The Nonroad Small SI Industry



1.2 Manufacturers of Marine Spark-Ignition Engines

The Marine SI industry is dominated by recreational applications with some commercial use and includes markets for several types of boats, personal watercraft (PWC), and SI engines that power them. The industry profile presented in the "Industry Profile for Marine SI Industry" report by RTI describes producers and consumers for each market segment; product attributes and the effects of these attributes on production costs and demand are described as well. As part of the market characterization, particular emphasis is placed on assessing suppliers' industrial organization and cost of production and demanders' price responsiveness and substitution possibilities. The Marine SI industry is divided into three applications areas: outboard (OB) boats, sterndrive and inboard (SD/I) boats, and PWC.

1.2.1 OB Boats

An OB boat is a vessel powered by one or more gasoline engines, which are located outside the hull at the back of the boat. The engine and drive unit are combined in a single package. An engine can easily be removed from the boat for inspection or repair, and it is quite common for the boat owner to change engines during the life of the vessel. The OB boat segment is the largest of the three application areas; in 2002, 213,000 units were sold, which is more than the combined sales of SD/I and PWC.

The OB application area can be further divided into "recreational" and "luxury" categories. The luxury category includes more-expensive vessels, for which the engine constitutes only a small portion of the cost of the entire vessel. The NMMA distinguishes between 14 types of OB vessels, 10 of which are considered recreational and 4 luxury.

1.2.2 SD/I Boats

SD/I vessels have an engine installed inside the hull of the vessel. An inboard vessel is a boat in which the engine is located inside the hull at the center of the boat with a propeller shaft going through the rear of the boat. A sterndrive (or inboard/outboard) vessel is a boat in which the engine is located inside the hull at the back of the boat with a drive assembly couple directly to the propeller. propeller shaft going through the rear of the boat. In contrast to OB vessels, SD/I vessels' engine is an integral part. Removal or replacement is significantly more difficult, so most repair work is done with the engine in place. Just like OBs, the SD/I application area is divided into recreational and luxury categories.

1.2.3 PWC

According to the Personal Watercraft Industry Association (PWIA), a PWC is defined as a "vessel with an inboard motor powering a water jet pump as its primary source of motive power, and which is designed to be operated by a person sitting, standing, or kneeling on the vessel."

The PWC application area is divided into the entry level, high end, and performance categories based on the horsepower ratings of the vessel. These categories correspond to 50 to 100 hp, 100 to 175 hp, and over 175 hp accordingly. Our study considers two categories that were available in 2002: entry level and high end. The performance category was introduced in 2003.

1.2.4 Marine SI Engines

Some OB engine manufacturers specifically build their engines to be incorporated into boats produced by another division within the same parent company. Other manufacturers produce and sell their engines to independent OB boat builders or consumers who need a replacement engine. SD/I engine manufacturers typically build custom engines for SD/I boats by marinizing automotive engines. All PWC vessel manufacturers build their own engines for

their vessels

Marine SI engines sold today are a mix of three primary technologies: crankcase scavenged two-stroke engines, direct-injection two-stroke engines, and four-stroke engines. Table 6.2.2-11 in Chapter 6 presents our best estimate of the technology mix for OB and PWC engines by power class. This technology mix is based on data submitted by manufacturers when the certify to our existing HC+NOx exhaust emission standards. Prior to the implementation of the existing standards, the vast majority of outboard and PWC engines were crankcase scavenged two-stroke engines.

The following Figures show the flow of engines from the engine manufacturer to the consumer for the different engine types.

Figure 1-2. OB Marine Economic Model Conceptual Flow Chart

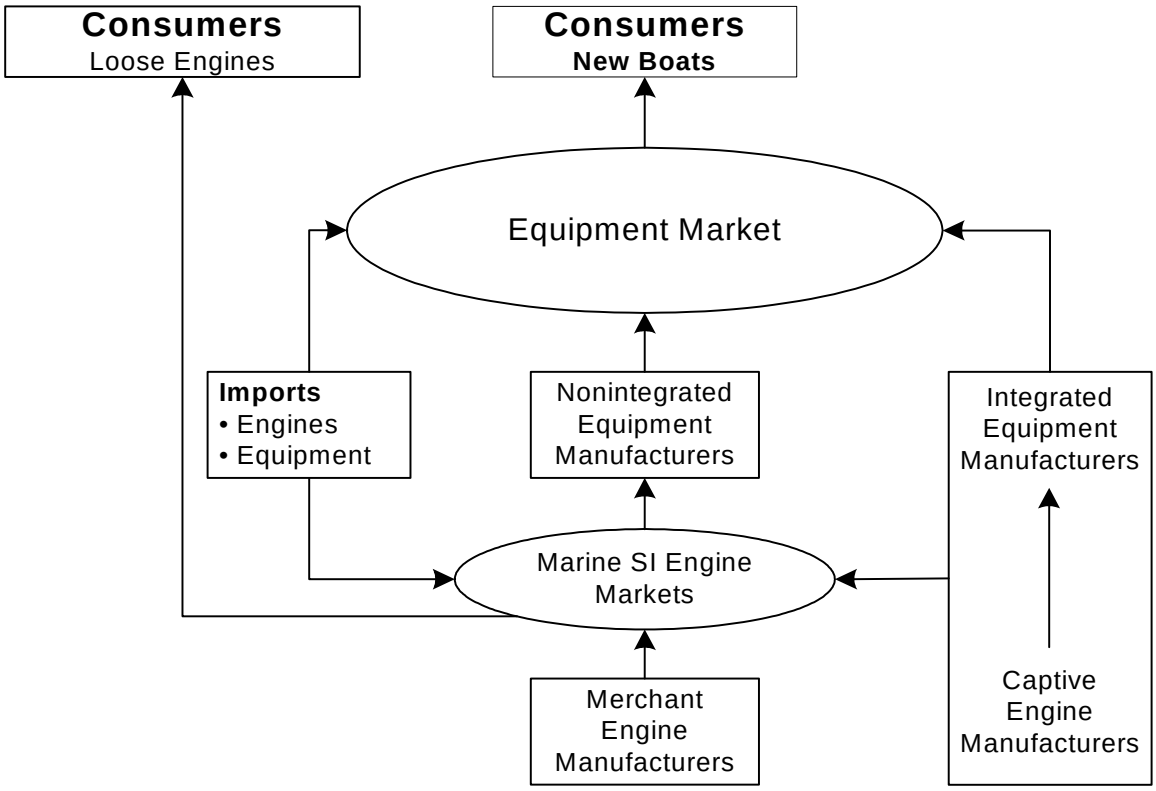


Figure 1-3: PWC Economic Model Conceptual Flow Chart

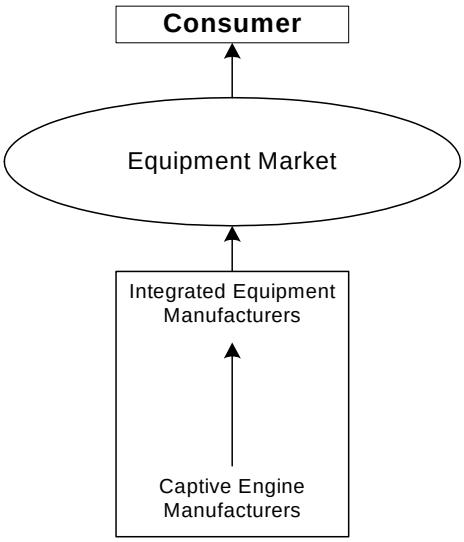
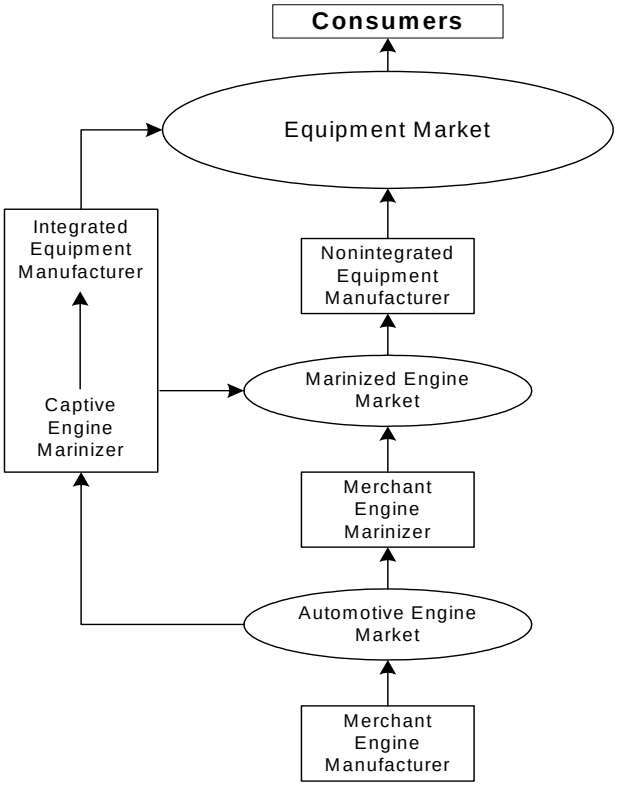


Figure 1-4: Inboard Marine Economic Model Conceptual Flow Chart



1.3 Fuel System Components

The primary fuel system components that would be affected by the rule are the fuel tanks and fuel lines on affected equipment and vessels. This section gives an overview of the production practices for these products.

1.3.1 Fuel Tank Production Practices

Plastic fuel tanks are either blow-molded, injection-molded, or rotational-molded. Generally, portable, PWC, and mid-sized Small SI fuel tanks are blow-molded. Blow-molding involves forming polyethylene in large molds using air pressure to shape the tank. Because this has high fixed costs, blow molding is only used where production volumes are high. This works for portable fuel tanks where the volumes are high and a single shape can be used for most applications. For portable tanks, the fuel tank manufacturer will generally design the tank, then send it out to a blow molder for production.

Smaller fuel tanks used in Small SI equipment are often injection-molded. In the injection molding process, fuel tanks are formed by forcing heated plastic into molds at high pressure. Generally, two fuel tank halves are formed, which are later fused together. This process requires high tooling costs, but lower total fixed costs than blow-molding. Injection-molding is typically used for smaller fuel tanks and has the advantage of giving manufacturers the ability to work with complex tank designs.

Larger fuel tanks used on Class II equipment and in boats with installed fuel tanks are typically rotational-molded out of cross-link polyethylene. Rotational-molding is a lower cost alternative for smaller production volumes. In this method, a mold is filled with a powder form of polyethylene with a catalyst material. The mold is rotated in an oven; the heat melts the plastic and activates the catalyst which causes a strong cross-link material structure to form. This method is used for Class II fuel tanks where the tanks are unshielded on the equipment. These fuel tanks also used meet specific size and shape requirements for boats and are preferred because they do not rust like metal tanks, but at the same time are more fire resistant than high-density polyethylene fuel tanks.

Metal fuel tanks are also used on both Small SI equipment and boats. Typically, metal tanks on Small SI equipment are made of steel. These tanks are typically stamped out in two pieces and either welded or formed together with a seal. Aluminum fuel tanks are also used primarily for installed marine fuel tanks because aluminum is more resistant to oxidation than steel. In the marine industry, tank manufacturers generally custom make each tank to meet the boat manufacturers needs. Generally, sheet aluminum is used and is cut, bent, and welded into the required configuration.

1.3.2 Fuel Hose Production Practices

Marine hose is designed to meet the Coast Guard performance requirements as defined by the Society of Automotive Engineer's recommended practice SAE J 1527. For fuel supply

lines, this includes a permeation rate of 100 g/m^2/day at 23°C (Class 1). For other fuel hose not normally continuously in contact with fuel (vent and fuel fill neck), the permeation standard is 300 g/m^2/day (Class 2). In general, boat builders will use Class 1 hose for both fuel supply and vent lines for simplicity. Some boat builders use low permeation barrier hose, for which, specifications are now included in SAE J 1527. For fuel fill necks, boat builders generally use Class 2 hose. Small SI hose is typically produced to manufacturer specifications. However, manufacturers may specify hose based on industry standards such as those listed in SAE J30.

Most fuel supply and vent hose is extruded nitrile rubber with a coating for better wear and flame resistance. Hose may also be reinforced with fabric or wire. (In contrast, plastic automotive fuel lines are extruded without reinforcement and are generally referred to as "tubing.") Hose manufacturers offer a wide variety of fuel hoses including those with a barrier layer of low permeability material, such as nylon, THV, FKM or ethyl vinyl alcohol, either on the inside surface or sandwiched between layers of nitrile rubber. These technologies are discussed in more detail in Chapter 5.

Fuel fill hose used on boats is generally manufactured by hand wrapping layers of rubber and reinforcement materials around a steel mandril. This hose is then heated to cure the rubber. Fuel fill hose generally has a much larger diameter than fuel supply and vent hose and this process offers an effective method of producing this larger diameter hose.

Pre-formed fuel lines are made in two ways. The first, and more common method, is to cut lengths of extruded hose, before it is vulcanized, and slip them over a contoured mandril. The hose is then vulcanized in the oven on the mandril to give it a preformed shape. The second way, primarily used on handheld equipment, but also for some outboard engine fuel system components, is to injection-mold small parts. To make the parts hollow, they are molded with a mandril inside. To remove the mandril, the part is typically inflated with air for just long enough to pull it off the mandril. Primer bulbs are also made in this manner.

Chapter 1 References

1. "Industry Profile for Small Nonroad Spark-Ignition Engines and Equipment," RTI International, October 2006.

2. "Industry Profile for Marine SI Industry," RTI International, October 2006.