Survey of Published Data and Reports on Blended Fuels in Marine Applications

2011 Report to Congress

January 12, 2012

Homeland Security

United States Coast Guard

Foreword

01/12/2012

I am pleased to present the following report, "Survey of Published Data and Reports on Blended Fuels in Marine Applications" which has been prepared by the United States Coast Guard.

Section 620 of the *Coast Guard Authorization Act of 2010* (P.L. 111-281) directs the Secretary of Homeland Security, acting through the Commandant of the Coast Guard, to submit a survey of published data and reports pertaining to the use, safety, and performance of blended fuels in marine applications.

Pursuant to congressional requirements, this report is being provided to the following Members of Congress:

The Honorable John L. Mica
Chairman, House Transportation and Infrastructure Committee

The Honorable Nick J. Rahall II
Ranking Member, House Transportation and Infrastructure Committee

The Honorable John. D. Rockefeller IV
Chairman, Senate Commerce, Science and Transportation Committee

The Honorable Kay Bailey Hutchinson
Ranking Member, Senate Commerce, Science and Transportation Committee

I am happy to answer any further questions you may have, or your staff may contact my Senate Liaison Office at (202) 224-2913 or House Liaison Office at (202) 225-4775.

Sincerely,

R. J. Papp, Jr.
Admiral, U. S. Coast Guard
Commandant

Executive Summary

Section 620 of the *Coast Guard Authorization Act of 2010* (P.L. 111-281) directs the Secretary of Homeland Security, acting through the Commandant of the Coast Guard, to submit a survey of published data and reports pertaining to the use, safety, and performance of blended fuels in marine applications not later than 180 days after the enactment of the Act.

To the extent possible, the survey shall include data and reports on: (A) the impact of blended fuel on the operation, durability, and performance of recreational and commercial marine engines, vessels, and marine engine and vessel components and associated equipment; (B) the safety impacts of blended fuels on consumers who own and operate recreational and commercial marine engines and marine engine components and associated equipment; and (C) fires and explosions on board vessels propelled by engines using blended fuels.

- An internet search using the search words "ethanol in marine applications" produces almost 100,000 results. A survey of the very large volume of articles regarding this issue was conducted by the Coast Guard to provide the members of Congress with the information that is currently available on the effects of ethanol as a gasoline additive on the marine industry and boat owners and operators. A representative sampling of the various types of documents that have been published was used in preparing this report.

- Although many studies using scientifically proven procedures have been conducted on the blending of various levels of ethanol as a gasoline additive in automobiles, there have been few such studies conducted on marine engine and fuel systems, and the test procedures were very limited. The Environmental Protection Agency (EPA) has recognized this in both an initial waiver granted to allow up to 15 percent ethanol blending in cars and light trucks built since 2007, and a follow-on waiver to allow up to15 percent ethanol blending in cars and light trucks built between 2001 and 2006. Both waivers exempted boat engines because, as stated in the waivers, current testing data do not support such a waiver.

- The limited testing of ethanol blending that has been performed on marine engines has raised some environmental, performance, and safety issues that have yet to be resolved and are of concern to the Coast Guard. In the Coast Guard's submittal of comments to the docket of the EPA, "Notice of Receipt of a Clean Air Act Waiver Application to Increase the Allowable Ethanol Content of Gasoline to 15 Percent" (74 Federal Register 18,228 of April 21, 2009), the Coast Guard concluded: "Only after a comprehensive study, including accelerated aging tests, is complete, will sufficient data be available to determine whether or not specific ethanol fuel blends pose an increased risk of injury to the boating public."


U.S. DEPARTMENT OF
HOMELAND SECURITY

Survey of Published Data and Reports on Blended Fuels in Marine Applications

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I. Legislative Language

This report responds to the language set forth in section 620 of the *Coast Guard Authorization Act of 2010*, which states,

SEC. 620. STUDY OF BLENDED FUELS IN MARINE APPLICATIONS

(a) SURVEY.—

(1) IN GENERAL.—Not later than 180 days after the date of enactment of this Act, the Secretary of Homeland Security, acting through the Commandant of the Coast Guard, shall submit a survey of published data and reports, pertaining to the use, safety, and performance of blended fuels in marine applications, to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate.

(2) INCLUDED INFORMATION.—To the extent possible, the survey required in subsection (a), shall include data and reports on—

(A) the impact of blended fuel on the operation, durability, and performance of recreational and commercial marine engines, vessels, and marine engine and vessel components and associated equipment;

(B) the safety impacts of blended fuels on consumers that own and operate recreational and commercial marine engines and marine engine components and associated equipment; and

(C) to the extent available, fires and explosions on board vessels propelled by engines using blended fuels.

II. Background

The phasing-out of the use of Methyl Tertiary Butyl Ether (MTBE) as an oxygenate gasoline fuel additive began in 2000 due to environmental concerns regarding incidents of ground water contamination. This phase-out opened the door for alternative oxygenate fuel additives such as ethanol. The passage of the *Energy Policy Act of 2005*, which repealed the *Clean Air Act* requirement to use MTBE or other oxygenates as fuel additives, resulted in ethanol becoming the gasoline fuel additive of choice. A gasoline blend of ten percent ethanol (E10) had long been approved by the EPA through a 1978 waiver to the *Clean Air Act.*

The transition from MTBE blended gasoline to E10 blended gasoline was relatively seamless for many gasoline users. Few problems arose from the widespread use of E10 in automobiles. Such was not the case, however, for the boating community. Upon the introduction of E10 to the boating community, some vintage boats experienced problems with ethanol-blended fuels resulting in catastrophic damage. These instances almost exclusively involved the installation of fiberglass fuel tanks in boat models older than 1981.[1] Other problems involving fuel system clogging, leaking gaskets, rough engine performance, and engine stalling were attributed to the use of E10.[2]

There have only been a few tests performed on marine engines using E10 and higher ethanol blended fuels, and the test parameters were very narrow in scope and did not include testing of the entire fuel system as well as the engines. Testing did not include normal usage over an extended period of time. . There is a much larger percentage of ten-year and older boats and marine engines in use than automobiles. Boats, especially fiberglass boats, can easily be in service for thirty years or more.

To date, there has not been enough research and testing of the use of ethanol blended fuels on marine engines and marine fuel systems and the impact of these fuels on the marine community. A much more comprehensive study of ethanol blended fuel use in boat fuel systems is necessary to determine the effect of ethanol blended fuels on the operation, durability, performance and safety of marine engines and marine fuel systems.

III. Analysis

There are voluminous published reports and data pertaining to the use, safety, and performance of ethanol-blended fuels in automobile applications, but little or no useful data or reports to fully determine the effect of ethanol blended fuels in similar marine applications. A review of the information available on the use of ethanol-blended fuels, especially E10, in marine applications reveals that there are two views regarding the issue. Supporters would like to increase the level of ethanol in blended fuels. The other view, mainly from the boating community, is that the long

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[1] See Renewable Fuels Association, *Ethanol and Engines*, January 2010; and *Boat U.S. Magazine*, "Ethanol Suspect in Fiberglass Gas Tanks," January 2006.

[2] See Fuel Testers, "Ethanol E10 Use in Marine Engines," January 2011; and The Outboard Wizard – Evinrude Parts, "Boat Engines – Dangers and Precautions Necessary with E10 Ethanol-Blend Gasoline," December 2010.

term effects of ethanol blended fuels on marine engines and marine fuel systems should be thoroughly researched and tested, as was done with automobiles.

Supporters of ethanol-blended fuels have taken the position that enough testing has been conducted to determine that, if boat owners take proper precautions, E10 should not be a problem in the marine environment.[3] One article discussing the winterization of boats states:

> "Ethanol and gasoline are completely miscible. If excessive moisture is introduced to the ethanol/gasoline fuel mixture, the ethanol and water can phase separate (fall out of suspension) from the fuel blend. This would result in a mixture of ethanol and water in the bottom of the fuel tank. Aside from the fact that the engine would not operate on this ethanol/water blend, it can also cause corrosion of the various metals with which it comes in contact. Such occurrences are rare, especially if proper maintenance and storage recommendations are followed. As a regular maintenance item and prior to a boating trip, check for water contamination of the fuel tank. If any water is found, remove all water and dry the fuel tank completely before re-fueling. Also, since some E10 can absorb moisture, it is important to have a tight fitting cap on both your equipment fuel tank and any gasoline storage containers."[4]

This recommendation regarding removing water from a water-contaminated fuel tank fails to take into consideration that the only access to a 50 gallon or larger fuel tank, located in the bilge of the boat, is through the fill tube. Additionally, the recommendation to have a tight fitting cap on the fuel tank fails to take into account that the Coast Guard, in 33 CFR §183.520(a), requires each fuel tank to have a vent system to prevent over-pressurization of the entire fuel system. The vent system is open to the atmosphere and, since boats operate in a moisture rich environment, it is not uncommon to have some amount of water enter the fuel tank. The problem of water in the fuel tank has historically been minimal in nature but becomes exacerbated by the ability of ethanol to absorb water and fall out of suspension to the bottom of the fuel tank where the fuel pick-up tube is located. The water can also increase the possibility of corroding aluminum fuel tanks. Corrosion of aluminum fuel tanks has long been recognized as a problem in boats, but will likely become a greater problem with greater use of E10.[5] Any increase in the level of ethanol in the fuel blend will allow for additional water absorption and increase the likelihood of the occurrence of corrosion.[6]

Ethanol supporters also state that most marine engine manufacturers allow the use of ethanol fuels in their products.[7] This is not the case for the many engines manufactured prior to the late 1990s, which were not designed for E10 and may need modifications to enable its use. The use of E10 in newer marine engines requires strict adherence to the manufacturer-recommended maintenance schedule and additional precautions. One of the precautions regarding E10 is that

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[3] Renewable Fuels Association, *Ethanol and Engines.*
[4] Renewable Fuels Association, *E10 and Winterization*, December 2010.
[5] U.S. Coast Guard, "There are no "maintenance free" metallic fuel tanks," *Boating Safety Circular #79*, April 1997.
[6] National Marine Manufacturers Association, "The Negative Affects of Ethanol on Recreational Boat Fuel Systems."
[7] Renewable Fuels Association, *Engine Facts: Engine Performance*, January 2011.

it should be replaced in the fuel tank every two to four weeks to minimize fuel phase separation and degradation and the problems that arise from it.[8] This recommendation may present a problem for boaters since normal usage of many boats is only occasionally during the boating season. It is also recommended that a water separating filter be installed in the fuel line to the engine. Many older boats, however, may not have a water separating filter.[9]

Ethanol supporters recognize that ethanol's solvency effect removes deposits, such as tars and gums in the fuel tanks and fuel systems of older boats. Therefore, it is recommended that extra fuel filters be added to the fuel systems of these boats and changed frequently.[10] The solvency effect of ethanol, however, has led to reports of stalled marine engines caused by clogged fuel filters and damage to engines caused by impurities passing through fuel filters.[11] This could pose a safety issue since the fuel filters can become clogged without warning and cause the engines to stall unexpectedly and potentially place the occupants of the boat in a hazardous situation.[12]

There are also reports stating that E10 may cause certain rubber-like parts used in older marine fuel systems, such as fuel hoses and gaskets, to fail and cause fuel system leakage.[13] Supporters state that automobile manufacturers solved this problem many years ago by upgrading the materials used in these components. That is not yet the case in the boating industry, especially for the almost 12 million registered mechanically-propelled boats already on the water.[14] Failure of gaskets and hoses poses a safety concern as fuel leaks very often are the cause of fires and explosions aboard boats. As to this possible safety concern, the Coast Guard cannot determine whether a leak caused by ethanol may actually be the cause of a fire or explosion.

Boaters with older marine engines and fuel systems appear to be having problems with the use of E10.[15] There is anecdotal evidence that marine engine problems are assumed to be caused by the use of E10, but very little scientific evidence to validate these assumptions. The preponderance of these complaints, however, begs further investigation into the actual affect of E10 on marine engines.

A 2003 test conducted by the Orbital Engine Company for the Australian Department of Sustainability, Environment, Water, Population and Communities on ten new 15 HP Mercury outboard engines using E0, E10, and E20 fuel blends showed, in general, that there was a degradation of engine performance with ethanol fuel blends, and the degradation increased with increasing ethanol content. Engine misfires and stalling occurred with greater frequency while

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[8] Fuel Testers.
[9] Ibid.
[10] Renewable Fuels Association, *Update for Boat Owners: Ethanol Blended Fuels for Use in Marine Equipment,* December 2010.
[11] See Scott Sandsberry, "The Ethanol Conundrum," *Yakima Herald Republic* (06 May 2009); and Chris Szepessy, "Avoid the Ethanol Blues," *Wind Check Magazine* (February 2011).
[12] See Sandsberry.
[13] See The Outboard Wizard, and Fuel Testers.
[14] U.S. Coast Guard, "Recreational Boating Statistics 2009," 28 July 2010.
[15] Sandsberry.

operating the engines on both E10 and E20 fuel blends. There was difficulty in maintaining boat speed during trolling when operating the engines with the E20 fuel blend.[16]

There has also been a limited test of E20 fuel in marine fuel tanks. A 2008 study was performed using six marine fuel tanks filled with E20 in a laboratory setting over a three-month period.[17] The most significant results from this study were the large increase of unwashed gum content in the used fuel samples, compared to the fresh samples. In addition, the E20 fuel mixture used in the test had a lower estimated net heating value, which would likely result in fewer miles per gallon. No phase separation was observed during the testing.

The National Renewable Energy Laboratory (NREL) recently completed two studies on the effects of ethanol fuel blends in marine engines. One study evaluated the effects of E15 on emissions and durability of a popular stern-drive 4.3L engine manufactured by Volvo-Penta.[18] The other study evaluated the effects of E15 on emissions and durability of three popular outboard marine engines manufactured by Mercury Marine – a 300 HP 4-stroke, supercharged, Verado, a 200 HP 2-stroke, 2.5L, EFI, and a 9.9 HP 4-stroke, carbureted engine.[19]

The results of the Volvo-Penta stern-drive engine test running on E15 versus E0 showed that the engine running on E15 suffered no noticeable mechanical damage, but it did not start easily when either cold or hot. Emissions tests showed that the emissions degraded such that the engine would not comply with current California emissions limits before the end of expected useful life. It was noted that fuel consumption increased with E15 when compared to E0 fuel.

The results of the outboard engine testing on the 300 HP Verado showed that the engine generated Hydrocarbon and Nitrous Oxide (HC+NOx) emissions in excess of Federal Emission Limits when operating on E15 fuel. The exhaust valves failed on the engine operating on E15 fuel due to excessive metal temperatures that caused a reduction in fatigue strength. The 200 HP 2-stroke engine operating on E15 showed no difference in emission deterioration, but did experience a higher than normal rod bearing failure rate after 250 hours in the test cycle. The root cause of the failure was indeterminate due to the degree of damage, but because the failure occurred so late in the testing, it raised concern on the effect of ethanol on oil dispersion in two-stroke engines. The 9.9 HP engine running on E15 fuel showed high HC variability at the post-endurance emissions testing. It is believed that this engine was misfiring at idle due to lean operation. This engine showed evidence of hotter metal temperatures due to carbon deposits, etc., and showed signs of gasket deterioration on the fuel pump. Despite the limited scope of the project and the fact that the sample size was insufficient to have statistical significance, several issues, such as durability failures, emissions issues, and run quality due to lean operation, suggest that more testing is necessary.

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[16] Orbital Engine Company, "Marine Outboard Driveability Assessment to Determine Impacts of a 10% and 20% Ethanol Gasoline Fuel Blend on a Small Batch of Engines," for the *Australian Department of Sustainability, Environment, Water, Population and Communities* (February 2003).

[17] Furey and Associates, LLC., "Analysis of E20 (20% Ethanol in gasoline) Fuel Samples from a Static Durability Test with Marine Fuel Systems," July 2008.

[18] Volvo-Penta North America, "4.3 GL E15 Emission and Durability Test," for the *National Renewable Energy Laboratory*, 2011.

[19] Brunswick Corporation, Mercury Marine Division, "High Ethanol Fuel Endurance Advanced Engineering Project," for the *National Renewable Energy Laboratory*, 2011.

IV. Conclusion

Although much information has been published regarding "ethanol in marine applications," only a few studies with any scientific rigidity have been conducted to date. The four studies have mixed results, but raise concerns regarding the use of ethanol in marine engines leading to the conclusion that more testing is necessary. Because tests were performed on new engines, they did not resolve concerns regarding the legacy fleet of older boats.

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