Testimony of David Hilbert

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Good afternoon, Chairman Harris, Ranking Member Miller, other members of the subcommittee.

It is a pleasure to be here this afternoon. My name is David Hilbert and I am a thermodynamic development engineer for Mercury Marine, a division of the Brunswick Corporation, located in Fond du Lac, Wisconsin. Mercury Marine has been a manufacturer of recreational marine engines continuously since 1939, and currently makes and sells more marine engines than any other manufacturer in the world. I am here today to testify on behalf of the National Marine Manufacturers Association, which represents over 1500 boat builders, marine engine, and marine accessory manufacturers.

I was the technical leader of a test of E15 blend fuel in three different Mercury outboard engines. These tests were conducted at the Mercury Marine test facility in Fond du Lac in 2010-2011 by Mercury personnel under contract to the US Department of Energy and coordinated by the National Renewable Energy Lab (NREL). The final report was released by the Department of Energy in October 2011.

The objective of these tests was to understand the effects of running a 15% ethanol blend on outboard marine engines during 300 hours of wide open throttle (WOT) endurance testing—a typical marine engine durability test. Three separate engine families were evaluated. A 9.9 HP carbureted four-stroke engine and a 300 HP supercharged electronic fuel injected (EFI) four-stroke engine represented current products. A 200 HP electronic fuel injected (EFI) two-stroke engine was chosen to represent the legacy products still in widespread use today. Two engines of each family were evaluated. One test engine was endurance tested on E15 fuel, while a second control engine was endurance tested on ethanol-free gasoline.

The primary point to remember when considering this test is that ethanol, in any blend, is an oxygenator. E10 fuel has 3% oxygen while E15 fuel has 5%-6% oxygen. On a typical marine engine, this

additional oxygen makes the fuel burn hotter, and the higher temperatures can reduce the strength of the metallic components. In addition, ethanol can cause compatibility issues with the other materials in the fuel systems because of the chemical interaction.

I would like to show you some photos of the engine components after the endurance testing to illustrate the results of the testing.

We were able to complete the entire 300 hour test running E15 in the 9.9 HP engine. Test results indicated poor running quality, including misfires at the end of the test. The poor run quality caused an increase in exhaust emissions. In addition, there were increased carbon deposits in the engine on the underside of the pistons and on the ends of the rods indicating higher engine temperatures. You can see the difference in the carbon deposits in this photo. Additionally, deterioration of the fuel pump gasket was evident, likely due to material compatibility issues with the fuel blend. This deterioration of the gasket could lead to fuel pump failure, disabling the engine. The effect on the gasket is shown here.

The 300 HP four-stroke supercharged engine did not complete the endurance test on E15 fuel. The engine encountered a valve failure after 285 hours of endurance testing. As you can see from the photos, one valve broke apart, which ended the test, and two others developed cracks. I should mention that these are high-quality valves constructed of inconel, a high-temperature resistant alloy. Even so, when we did metallurgical analysis on this engine, we found that the cause of these fractures was deteriorated mechanical strength due to high metal temperature. The next photos show a comparison of the pistons and connecting rods from the Verado engine, also indicating that the E15 test engine operated at elevated temperatures.

The 200 HP two-stroke engine using E15 fuel also failed to complete the endurance test. It failed a rod bearing at 256 hours of testing, resulting in catastrophic destruction of the engine. You can

see the remains of the bearings in the photos. There was so much damage to the engine that we could not determine the exact cause of failure. It is important to note that two-stroke engines of this architecture mix the fuel and the oil and use that mixture to distribute the oil to the critical interfaces such as the bearings and cylinder walls. Ethanol may have an effect on the dispersion or lubricity of the oil as it is mixed with the fuel. More testing of such engines is necessary to understand the ramifications of an E15 blend fuel on this type of lubrication system, as it is not well understood at this time.

Despite the limited nature of this testing, several significant issues were identified. The testing was done on a small sample of engines running one operating point, wide open throttle. In addition to the need for more 2-stroke lubrication system testing, more testing is needed to understand how E15 fuel affects marine engines during other operating conditions. Examples would include starting, acceleration/deceleration, part-throttle operation, and the effect of E15 fuel on marine engines that are stored with fuel in the system over long periods of time, which occurs regularly with our engines.

What I have presented to you in brief today—and what is available at the NREL website in full—are the results of the limited testing conducted on three of Mercury's outboard engine families. Changes in fuel formulations and the resulting effects on marine engine operability are of high importance. This study showed how misfueling marine engines currently in use with E15 may cause a variety of issues for owners and can lead to premature engine failure.

Thank you for allowing me the opportunity to testify today.

To see the full report from the testing performed by Mercury Marine on outboard marine engines, please visit the following website:

http://www.nrel.gov/docs/fy12osti/52909.pdf

To view the companion report from the testing performed by Volvo Penta on sterndrive/inboard marine engines, please visit the following website:

http://www.nrel.gov/docs/fy12osti/52577.pdf