



ISO 9001:2008 Registered

FINAL REPORT

Emission and Performance Testing for Speed of Air Engine Technologies with Their Modified 5.9L Cummins Diesel Engine Compared to a Stock Unmodified 5.9L Cummins Diesel Engine

Prepared for:

Speed of Air Engine Technologies

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Reno, NV 89521

Prepared by:

Olson-EcoLogic Engine Testing Laboratory

Fullerton, California

Introduction and Objective:

This project was intended to measure the exhaust emissions and engine performance of proprietary Speed of Air engine modifications. The test engine provided by the client is a 5.9L Cummins engine. This is a Tier 0 off-road engine so no emission standards exist for this model. This engine was first tested in its stock configuration to provide baseline data. The engine was then re-fitted with Speed of Air Engine Technologies modified pistons. The test engine was then tested in Speed of Air's lab to achieve break-in of the new components and gather control data. Finally, the Speed of Air Engine Technologies modified engine was retested at the Olsen-EcoLogic lab in Fullerton to obtain a full set of comparative data.

Test Fuel:

The test fuel used for all tests is a commercially available ultra low sulfur (ULS) California specification diesel fuel with less than 15 ppm of sulfur.

Test Protocol:

The ISO-8178 8-mode test protocol has been used historically for emission testing of offroad heavy duty engines as described in 40 CFR Part 89. All test work for the project was conducted in full accordance with the ISO-8178 8-mode test protocol. The Olson-Ecologic complement of instruments is as described below.

<u>Pollutant</u>	<u>Instrument</u>	<u>Instrument Description</u>
CO	Horiba AIA23- CAI 600 Series	NDIR
CO2	Horiba AIA23- CAI 600 Series	NDIR
HC	California Analytical Model 600	Heated FID
NOx	CAI Model 400 HCLD Heated	Chemiluminescent
NO	CAI Model 400 HCLD Heated	Chemiluminescent
PM	AVL Smart Sampler	Secondary dilution

All measuring instruments are calibrated at regular intervals and the calibrations are traceable to NBS standards. All calibration gases are also traceable to NBS standards. Excerpts from the Olson-EcoLogic S.O.P. applicable to this project can be provided under separate cover. All calibrations are available for inspection and CARB has a confidential copy of the entire document.

ISO 9001:2008 registration requires semi-annual audit of all management and measurement records in addition to conventional monthly, weekly and daily instrument calibrations.

The emission testing protocol was conducted in the all electric Olson-EcoLogic engine dynamometer test facility using the ISO-8178-C1 8-mode steady-state testing procedure as previously required for certification of heavy-duty diesel engines for off-road applications. This operating test protocol involves the collection and analysis of emissions from a hotstart while operating the engine over 8-modes of specific loads at the engine rated constant speed under stabilized conditions. The detailed test cycle is as follows:

ISO-8178 8-Mode Test Cycle

Mode No.	Weighting Factor, %	RPM	Torque, %
1	15	Rated	100
2	15	Rated	75
3	15	Rated	50
4	10	Rated	10
5	10	Max torque, rpm	100
6	10	Intermediate	75
7	10	Intermediate	50
8	15	Idle	0

The engine was operated and emissions, including THC, NO_x, NO, CO and CO₂ were recorded every second each mode for five minutes to stabilize emissions. The last two minutes of each mode were recorded second-by-second and averaged to provide the stabilized steady-state emission/fuel economy results.

Particulate sampling consisted of collection from all 8-modes compositively on a preweighted single filter media as prescribed in the ISO-8178 8-mode test protocol.

Test Facility and Capability:

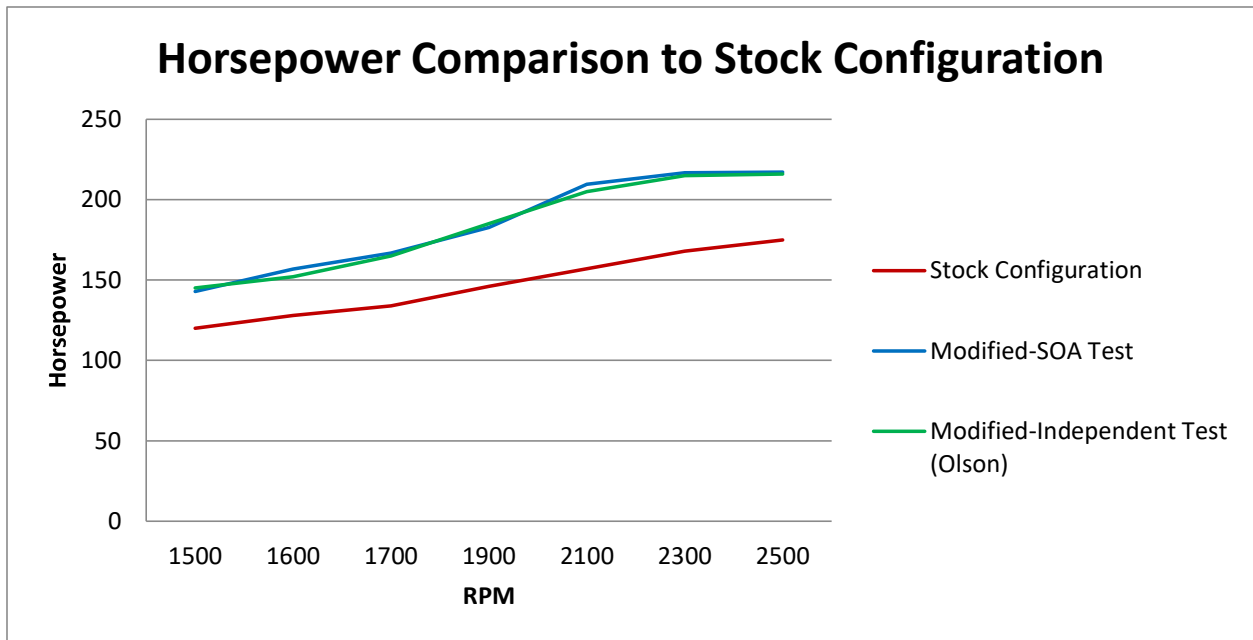
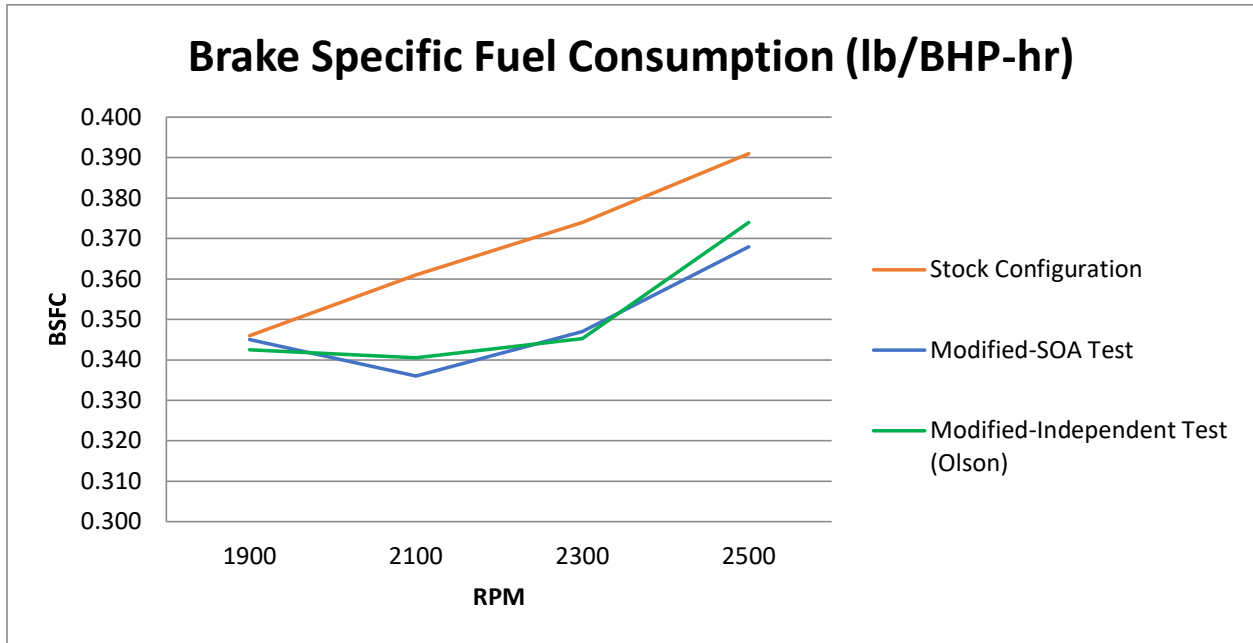
Olson-EcoLogic, an independent emission test laboratory, is an ISO 9001:2008 registered facility. The lab is officially recognized by the Texas Commission for Environmental Quality (TCEQ), CARB and listed by EPA as an emission test facility capable of the protocols provided in this project. Hundreds of emission tests have been submitted to, and accepted by, TCEQ and CARB for other clients. Over the years literally thousands of emission tests have been conducted for CARB review and in accordance with TCEQ, CARB and EPA requirements. All engine operation and emission testing for this project was conducted at the laboratory in Fullerton, California.

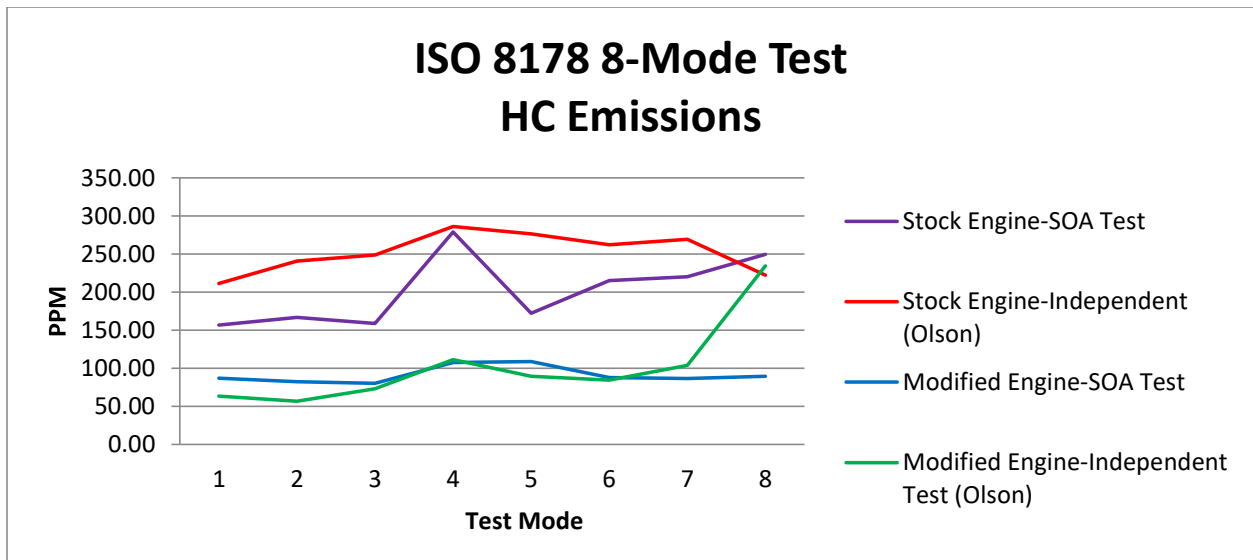
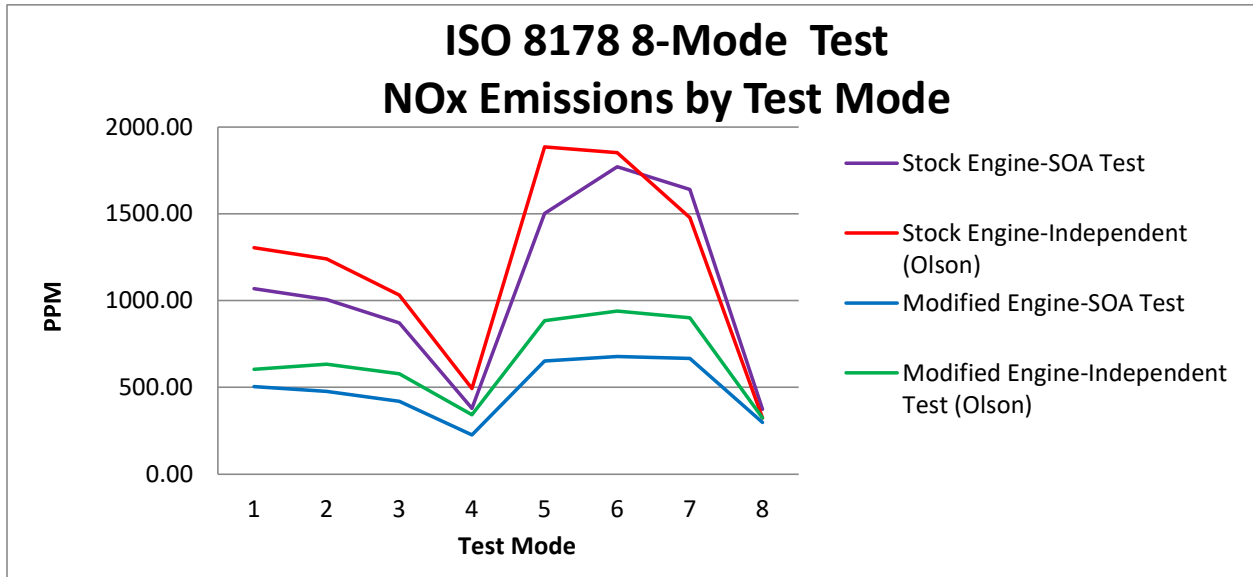
Emission Testing Measurements:

Engine and related test variables, including computer calculated values, recorded for every test, every second, over the test protocol include the following:

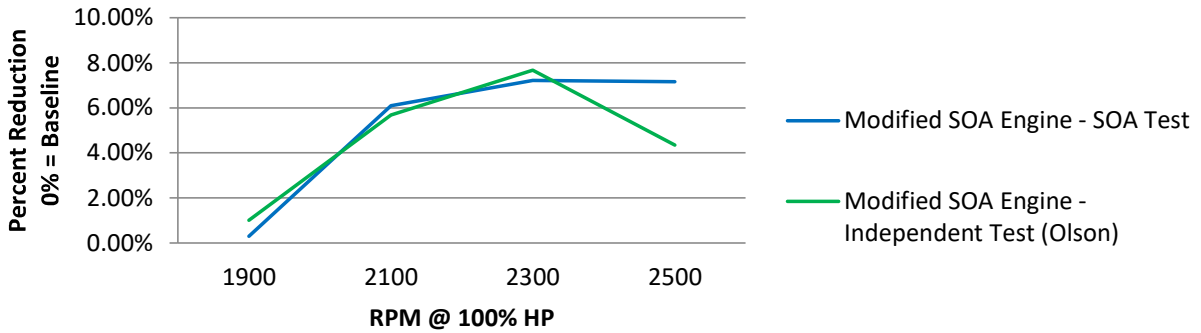
Work, horsepower
Speed, RPM
Torque, lb-ft
Horsepower
Oil Temperature, F
Coolant Temperature, F
Exhaust Temperature, F
Charge Air Temperature, F
Oil Pressure, PSIG
Boost Pressure, PSIG
Exhaust Back Pressure, in H ₂ O
Air Inlet Temperature, F
Manifold Vacuum, in H ₂ O
Barometric Pressure, in Hg
Relative Humidity, %
CO ₂ , %
CO, ppm
NO _x , ppm
NO, ppm
THC, ppm
Exhaust Temperature, C
Time, Hours
Time, Minutes
Time, Seconds

Test Results:





Percent Reduction in Fuel Consumption vs Stock Configuration



ISO 8178 8-Mode Test % HC PPM Emissions Reduction by Test Mode



