Fluid Economy Testing

IC Bus™ CE Series powered by a MaxxForce® 7 engine tested against a Blue Bird Vision with a Cummins ISB engine and a Thomas C2 with a Cummins ISB engine

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Abstract

The purpose of this initiative was to conduct head-to-head testing among competing school buses to validate claims relative to fluid economy (diesel + liquid urea DEF consumed). IC Bus commissioned a third party to conduct on-track testing following a simulated school bus stop and go type route and utilizing the TMC Type IV Fuel Economy standard with the addition of DEF Consumption. The test vehicles used were an IC Bus™ CE Series with a MaxxForce® 7 Advanced EGR engine, a Thomas® Saf-T-Liner® C2 with a Cummins ISB engine using SCR, and a Blue Bird Vision with Cummins ISB engine using SCR. Findings proved the IC Bus CE Series had up to 4.5% advantage on fluid economy in typical bus operating conditions and between 0.5 and 1.5% fluid economy advantage using TMC Type IV testing methods. The following document outlines testing methodology and detailed results.

Background

IC Bus commissioned a head-to-head fluid economy comparison of the following 2010 emissions-compliant buses:

- IC Bus CE Series powered by the MaxxForce 7 with Advanced EGR
- Thomas Saf-T-Liner C2 using a Cummins ISB with liquid urea SCR
- Blue Bird Vision using a Cummins ISB with liquid urea SCR

The intent of this testing was to provide clarity of competing claims in the marketplace and provide customers the information needed to make informed decisions in their upcoming bus purchases. Liquid urea SCR-powered bus and engine manufacturers have made a variety of claims, notably:

Competitor Claim	Comments
"Cummins EPA 2010 ISB6.7 and ISC8.3 engines are delivering up to 3% better fuel economy than our 2007 product- and the advantage versus EPA 2010 EGR-only engines is even better." [Cummins ad, *School Transportation News*, April 2011]	• No mention of liquid urea consumed, so not presenting the complete fluid economy picture. • No documentation to support how their advantage versus EPA 2010 EGR-only engines is "even better" than 3%.
"SCR technology, along with the Cummins engine, provides a long list of benefits over In-cylinder EGR, including a Cummins-tested fuel economy advantage of 5-9%…" [Thomas Built Buses ad, School Transportation News, May 2011]	• They reference their supplier's testing without any details. • Note that Cummins' own advertising does not make any claims to a 5-9% fuel economy advantage. • No mention of liquid urea consumed.
"Cummins engines teamed with Blue Bird school buses deliver 7-17%+ better fuel economy. Third-party independent tests confirmed!" [Blue-bird.com website, May 2011	• No explanation of what engines the 7-17%+ better fuel economy is comparing. • Cummins did publish test results for a Fuel Economy Comparison of a Blue Bird with Cummins ISB vs. an IC Bus CE Series with a MaxxForce DT in 2009. That testing did not use USEPA 2010 engines and did not achieve 7-17%+. • No mention of liquid urea consumed.

It should be noted that to be relevant to the current marketplace, all of these claims above should be comparing current versions of the Cummins ISB to the MaxxForce 7 in bus applications and therefore should be similar if not the same. IC Bus felt the most relevant measurement of performance for bus operators is to capture data in operating conditions common to the industry including idle time, low average speeds, and frequent stops and starts.

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Fuel Economy vs. Fluid Economy

With 2010 emissions, the rules changed and the common measurement of pure "fuel economy" needed to be revisited. Today different bus manufacturers offer different solutions for meeting 2010 emissions, and fuel economy doesn't tell the whole story. The competitors' buses use SCR (selective catalyst reduction) technology which require a liquid urea solution (also called "DEF") to operate the vehicle, and like diesel fuel, liquid urea costs money. Buses using SCR must consume liquid urea to comply with clean air regulations. That's why we use fluid economy as the measurement for bus comparisons. Fluid economy is a measurement of diesel fuel plus liquid urea consumed. This measurement provides a more complete representation of customers' operating costs.

Objective

The goal of this initiative was to contract a third party to conduct testing to measure and compare fluid economy for competitive 2010 emissions-compliant school buses in typical bus operating conditions. The production vehicles measured were similarly equipped and specified to provide fair test results.

Hypothesis

Until this testing, no claims have been proven through third party testing to show which bus and engine combinations lead the market on fluid economy performance. We believe that the IC Bus CE Series with the MaxxForce 7 engine, when compared to other 2010 emissions compliant buses, is the most efficient in fluid economy.

Methodology/Procedures

When fluid economy testing under TMC Type IV practices is conducted, numerous measures are taken to ensure stable testing controls and statistically reliable results. The test route used for this test was based off usage data and feedback from bus customers. We continually work with our customers to assure our test routes are appropriate for the applications. We designed this TMC Type IV test to account both for diesel fuel as well as urea.

a.) A complete test = a minimum of three valid test runs.

b.) Test Run = one run through the simulated bus route with stops and various speeds for 135 miles. The 135 mile test route represents multiple cycles of a typical school bus route.

c.) Data Point = the ratio of fluid burned during a test run divided by the fluid burned during a test run.

d.) Driver Switch Point = the point, which is every 45 miles of the test route, where drivers switch vehicles to eliminate driver influence of test results. Each driver drives each bus per test run.

e.) Valid Test Run/Valid Test = a test run resulting in a valid data point. A valid data point is a ratio within two percent of two other data points. Three valid data points comprise a valid test.

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Test Preparation

a.) Test Route Selection- a simulated bus route performed on a test track. The test route had speeds ranging from 0 to 50 MPH and contained multiple stops. The test track was used to alleviate any interference from public traffic and allows for highly controlled vehicle operation with repeatable results.

b.) Test Speed Selection- the test speed should be representative of fleet operation.

c.) Test Vehicle Specification and Configuration- test vehicles must be identical down to tire design, air pressure and tread remaining. The only variable should be the item being evaluated. When testing new vehicles with odometer mileage between 2,500 and 10,000 miles, the odometer readings of both vehicles should be within 1,000 miles of each other.

d.) Drivers- drivers who start the test must complete the test, and substitution is not permitted.

e.) Observers- if observers are used, they should have a contributing function and avoid distracting the driver.

f.) Weather Measurement- complete test summaries include environmental conditions: temperature, wind speed and direction, and relative humidity.

g.) Fuel Measurement- high accuracy fuel flow meters were used to measure fuel consumption. The flow meters were installed in such a fashion that only fuel consumed is measured. A fuel cooler was also incorporated to dissipate any heat from flow through the engine.

h.) DEF Measurement- DEF is measured gravimetrically and converted to gallons.

Vehicle Preparation

To minimize variability, all vehicles tested must be in similar mechanical condition, representative of the fleet's vehicles, and have the following:

a.) Handheld 2-way radios- enable drivers to keep vehicle conditions exactly the same.

b.) Each engine governor or electronically programmable drivetrain parameter set to manufacturer's recommendation or fleet standard and verification of electronic engine program settings.

c.) New fuel filters in all cases and new air cleaner elements.

d.) Each vehicle clean and free of damage and missing body parts.

e.) Side window openings the same in each vehicle at all times.

f.) Accessory load for each vehicle as consistent as possible.

g.) Axle alignment checked and adjusted to conform to manufacturer specifications.

h.) Each vehicle properly lubricated prior to test and fluid levels checked for prescribed levels.

i.) Temperature controlled fan drives and shutters in the same operating mode throughout the test.

j.) Cold tire pressures measured and inflated to standard.

k.) Stall checks performed on vehicles equipped with automatic transmissions and torque converters.

l.) Exhaust system back pressure below engine manufacturer's maximum recommended limit.

m.) Proper brake adjustment. Either disarm automatic slack adjusters or check for brake drag before, at mid-point and after each test run.

n.) Each vehicle loaded with equal ballast weights.

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Data Analysis and Conclusion

In school bus route testing, we observed up to a 4.5% advantage in fluid economy for the IC Bus CE Series over a competitor.

Single Best Test Run	IC Bus CE Series with MaxxForce 7 Advanced EGR	Competitor
Miles Driven (per test run)	135	135
Total Liquid Consumed	12.47	13.07
Fluid Economy Advantage	Up to 4.5%+	—

Data meeting the TMC Type IV criteria shows that the IC Bus CE Series with a MaxxForce 7 Advanced EGR engine has a fluid economy advantage between 0.5 and 1.5%.

Type IV Test Results	IC Bus® CE Series with MaxxForce® 7 Advanced EGR	Blue Bird Vision with Cummins ISB/ SCR	IC Bus® CE Series with MaxxForce® 7 Advanced EGR	Thomas Saf-T-Liner C2 with Cummins ISB/ SCR
Miles Driven (per test run)	135	135	135	135
Total Liquid Consumed	38.46	39.01	37.50	37.68
Fluid Economy Advantage	+1.5%	——	+0.5%	——

* Within the entire Type IV Testing, a maximum advantage of 4.5% fluid economy was seen by the IC Bus® CE Series with a MaxxForce® 7 Advanced EGR engine. This data was observed on a single run. However, this advantage was achieved under real world conditions which could be experienced by the customer.

Test Vehicle Specifications

	2010 IC Bus CE Series (MaxxForce 7)	2010 Thomas C2 (ISB)	2010 Blue Bird CV (ISB)
Wheel Base	276"	279"	273"
Passenger	77	77	72
Front Axle	10K	10K	12K
Front Susp	10K	10K	10K
Brakes	Hydraulic	Hydraulic	Air
Tires- Steer			
Brand	Goodyear	Goodyear	Goodyear
Model	G662	G662	G662
Size	11R22.5	11R22.5	11R22.5
Tires- Drive			
Brand	Goodyear	Goodyear	Goodyear
Model	G182	G182	G182
Size	11R22.5	11R22.5	11R22.5
Exhaust	Single Horz	Single Horz	Single Horz
DEF Tank	N/A	11.5 Gal.	15 Gal.
Alternator	320 AMP 12V	200 AMP 12V	240 AMP
Engine	MAXXFORCE 7	ISB	ISB
	220HP @ 2600 RPM	200HP @ 2300 RPM	200HP @ 2300 RPM
	560LB-FT	520LB-FT	520LB-FT
Trans	Allison 2500PTS 5-Spd	Allison 2500PTS 5-Spd	Allison 2500PTS 5-Spd
Rear Axle	19.8K	23K	21K
Ratio	5.29 RAR	5.22 RAR	5.29 RAR
Rear Susp	19.8K	23K	23K
Fuel Tank	65 Gal.	100 Gal.	100 Gal.
Test Weight	25,050 lbs.	24,920 lbs.	25,010 lbs.