Derive Ford 7.3L Fuel Economy Study

Conducted on behalf of Derive by the SEMA Garage

Overview- Derive Systems provides engine recalibration devices that offer fuel economy improvements and driver behavior tempering for fleet operators. The purpose of this project is to utilize an automotive emissions laboratory environment to accurately evaluate both the emissions and fuel economy impacts of Derive's efficiency products. However, standard emissions testing utilizes specifically repeatable drive traces (FTP-75, HWFET, US06, SC03, etc.) to evaluate a vehicle's emissions output versus emissions standards. This format is somewhat inadequate to provide a real-world fuel economy evaluation for this type of product due to the way that the modifications change driver behavior.

The process developed for evaluating this product includes measurement of emissions and fuel economy in an unmodified condition with a pattern that assumes aggressive driving style, similar to an urban delivery route, followed by testing in a modified condition with comparable driving style and over the same route but limited by the effect of the Derive product. Idle conditions were evaluated in isolation from the drive traces to allow for separate evaluation and combined with the drive trace results to illustrate comparative effect with and without extended idle time.

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Test Vehicle

The selected test vehicle is a 2021 Ford F-250 with a 7.3L gasoline engine. It was equipped with an AVL Plutron Fuel Flow meter which accurately measures fuel mass flow and volume flow and calculates fuel density. Fuel consumption was evaluated using the volume data from the Plutron. Fuel volume calculations were also backchecked by calculation using air-fuel ratio vs mass air flow from OBD datalogs and CO_2 measurements. A single batch of pump fuel was used over all tests to ensure consistency. Fuel quantity based on CO_2 measurements may be skewed due to unknown carbon content in the pump fuel but is useful for comparative evaluation.

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Test Plan

- Drove and recorded route in baseline condition. Route is representative of an urban delivery route, with stops at various locations and intermittent highway stretches. Driver behaved aggressively, with rapid accelerations and speeds at or slightly above the posted limit. Route is 29.7 miles in length.
- The recorded baseline route (speed over time) was adjusted to remove extended idle times. All stops were adjusted to 10 seconds. This allows for continuity between the baseline and modified drive traces.
- The route was repeated with the vehicle in modified condition. Speed limit was set during installation to 65 mph. Driver behaved aggressively in the same fashion as baseline but was tempered by the function of the modified calibration. Idle times were adjusted to 10 seconds.
- Both recorded routes were installed into the SEMA Garage emissions test cell chassis dynamometer control system. Both utilized a HWFET trace as a warmup cycle to ensure consistent starting conditions. Testing was conducted on both traces with a Plutron fuel flow meter and cumulative emissions capture (data not gathered during HWFET warmup).
- Testing was also conducted in similar fashion with a HWFET warmup followed by approximately 24 minutes of idle in both the baseline and modified conditions.
- All testing was done in triplicate to demonstrate repeatability.

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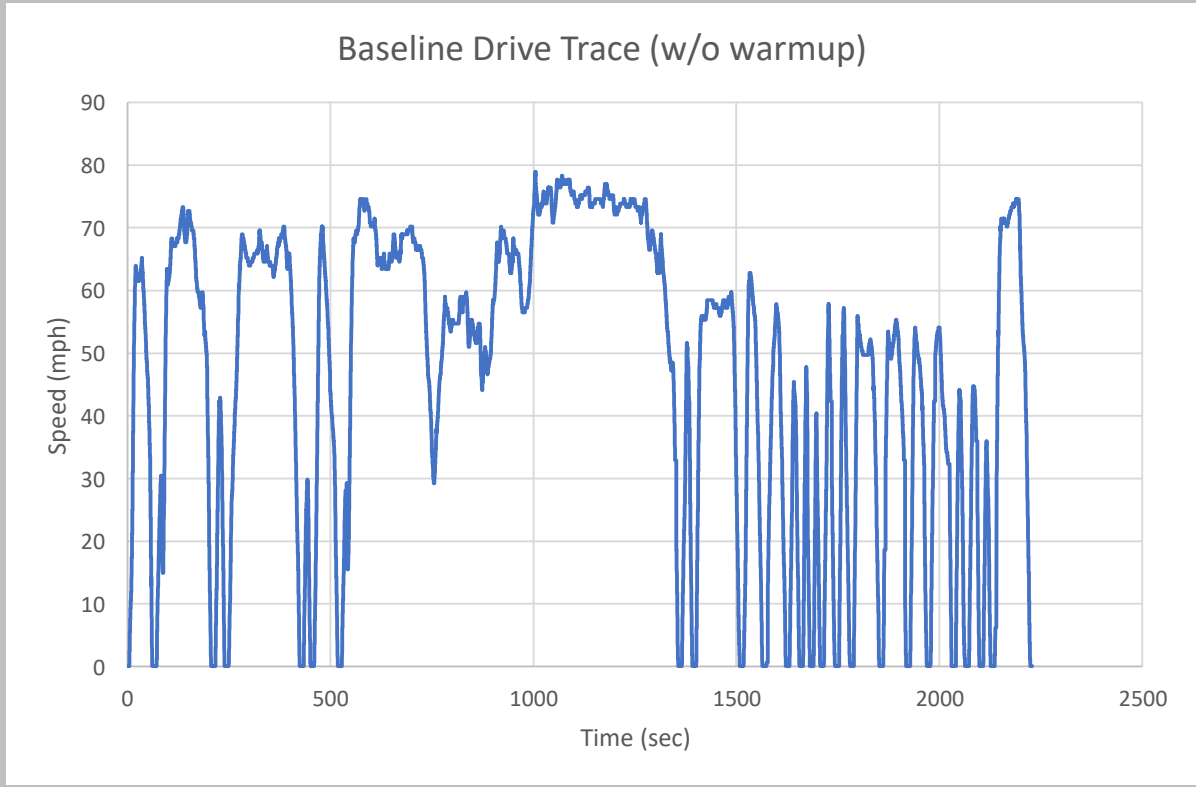
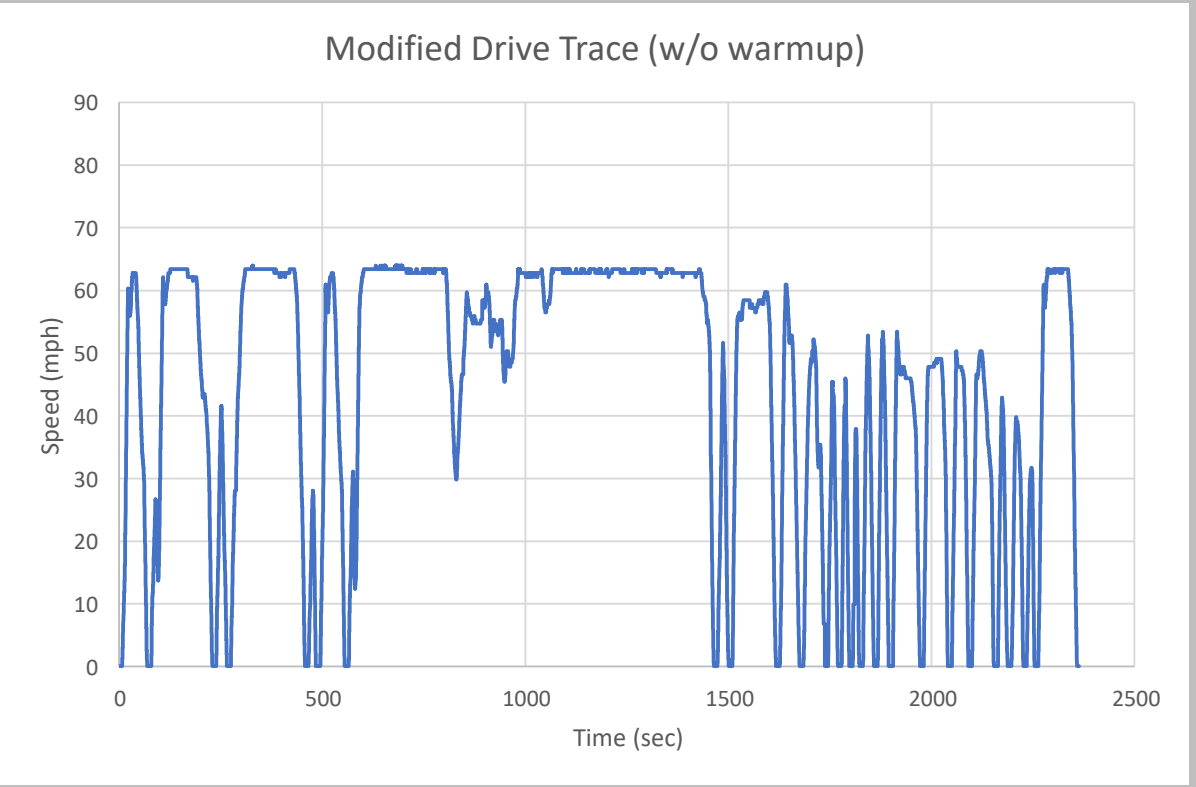
Drive Traces





Complete Drive Trace Results, Minimal Idle Time

Config.	Dist (mi)	Plutron Volume (gal)	FE (mpg)	Calc Volume (gal)*	FE (mpg)	CO2 (g)	FE** (mpg)
Baseline	29.64	2.901	10.22	2.797	10.60	21982	11.2
Baseline	29.68	2.910	10.20	2.835	10.47	22140	11.1
Baseline	29.62	2.881	10.28	2.797	10.59	21867	11.3
	AVG:	***2.897***	***10.23***	***2.810***	***10.55***	***21996***	***11.2***
Modified	29.68	2.482	11.96	2.447	12.13	19602	13.0
Modified	29.73	2.473	12.02	2.428	12.24	19688	12.8
Modified	29.68	2.507	11.84	2.450	12.11	19629	12.9
	AVG:	***2.487***	***11.94***	***2.442***	***12.16***	***19640***	***12.9***
	Delta:	***0.410***	***1.71***	***0.368***	***1.61***	***-2357***	***1.7***
		-14%	***17%***	***-13%***	***15%***	***-11%***	***15%***

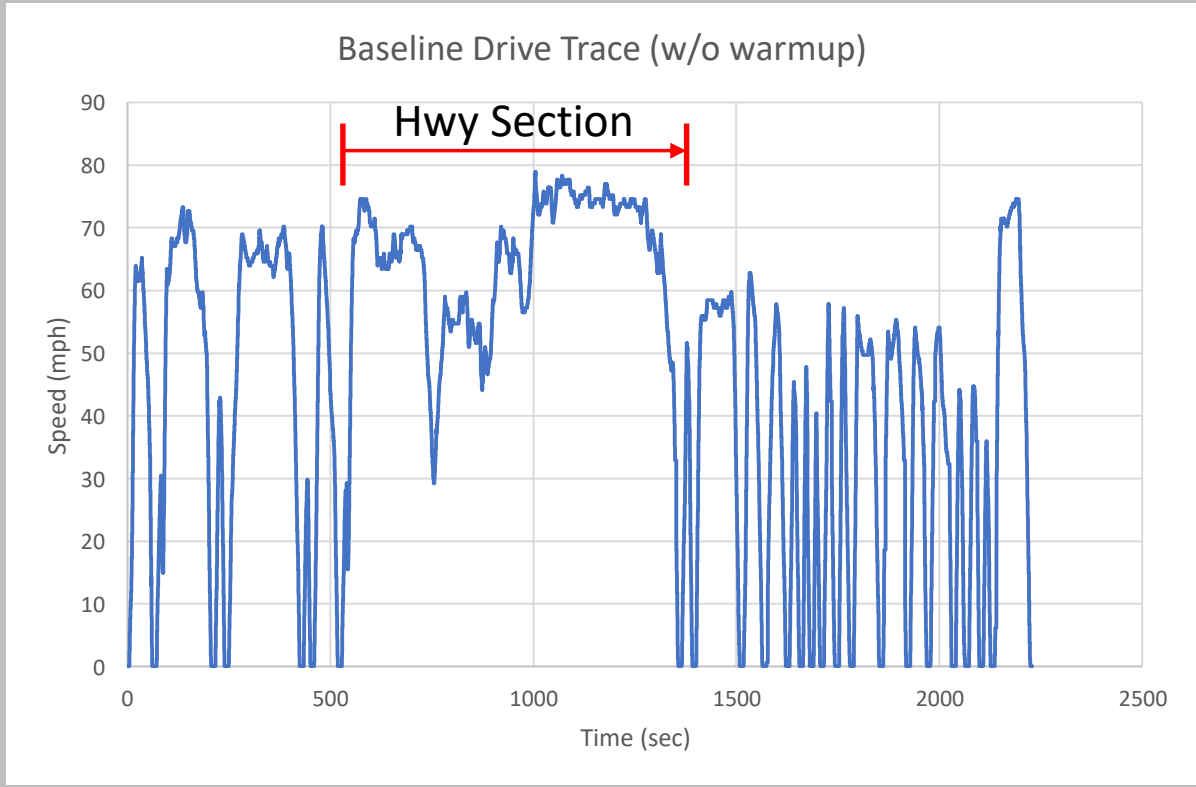
** Calculated from Mass Air Flow divided by Air Fuel Ratio, using fuel density data from Plutron*

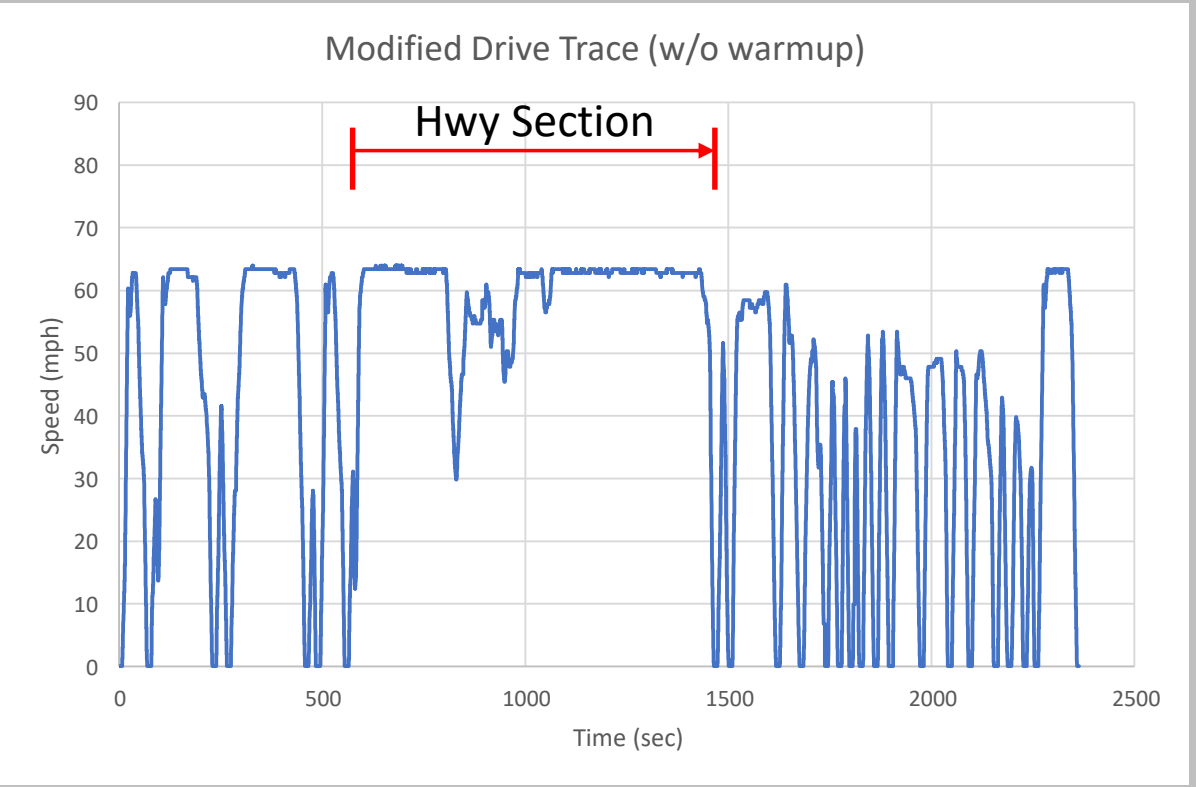
*** Based on CO2 measurement*

Observations

- Results generally show a high level of repeatability
- Fuel economy results indicate improvement via all evaluation methods
- Use of Plutron Volume evaluation recommended as it is the most direct measurement method
- All emissions showed improvement or even results (within 10%)

Highway Evaluation





Additional data analysis was done to evaluate fuel during the sustained highway portion of the drive trace.

Highway Results

Config.	Dist (mi)	Plutron Volume (gal)	FE (mpg)	Calc Vol. (gal)*	FE (mpg)
Baseline	14.70	1.181	12.45	1.142	12.87
Baseline	14.71	1.188	12.38	1.164	12.64
Baseline	14.69	1.178	12.47	1.157	12.70
	AVG:	***1.182***	***12.43***	***1.154***	***12.74***
Modified	14.71	1.004	14.65	0.956	15.39
Modified	14.70	0.983	14.95	0.941	15.62
Modified	14.67	1.008	14.55	0.962	15.25
	AVG:	***0.998***	***14.72***	***0.953***	***15.42***
	Delta:	***0.184***	***2.29***	***0.201***	***2.68***
		16%	***18%***	***17%***	***21%***

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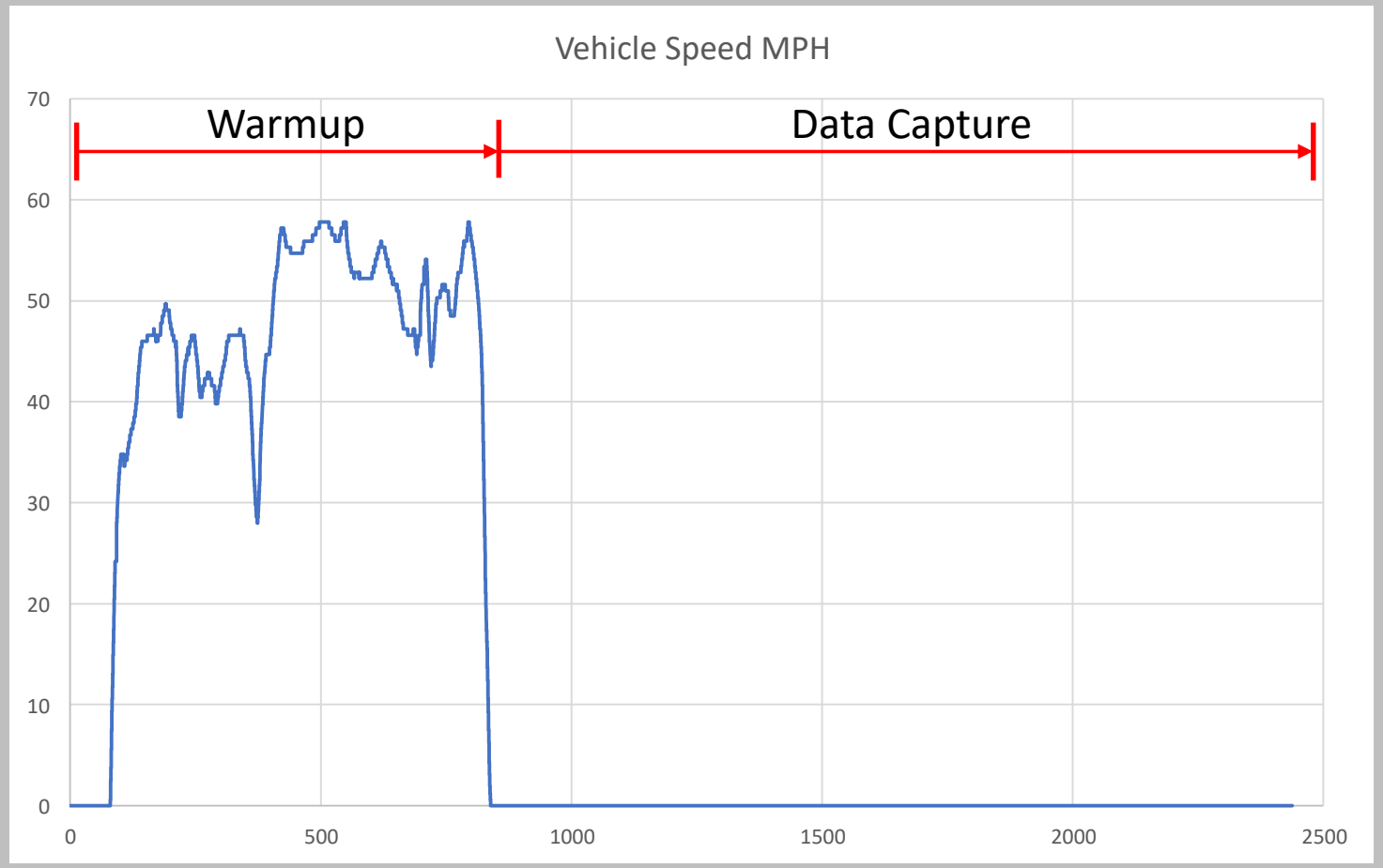
Idle Trace

Test includes a HWFET warmup followed by ~1500 seconds of idle. Data captured during idle only.



Idle Results

Condition	Avg Idle Speed (rpm)	Plutron Avg Mass Flow (kg/h)	Plutron Avg Vol Flow (l/h)	CO2 (g)
Baseline	600	1.643	2.340	2022
Baseline	599	1.671	2.410	2044
Baseline	600	1.676	2.431	2029
AVG:		***1.663***	***2.394***	***2032***
Released	550	1.515	2.180	1850
Released	549	1.501	2.157	1852
Released	549	1.516	2.182	1834
	AVG:	***1.511***	***2.173***	***1845***
	Delta:	***0.153***	***0.221***	***-186***
		9%	***9%***	***-9%***

Observations

- Results generally show a high level of repeatability
- Some unexplained variation in modified NMHC results, but not uncharacteristic for gasoline vehicles
- Fuel consumption results indicate improvement via both evaluation methods
- NOx and CO values are too low to effectively compare

Complete Drive Trace Results, Extended Idle Time

Drive Trace data and Idle data combined, represents ~24 minutes of idle

Config.	Dist (mi)	Plutron Volume (gal)	FE (mpg)	Calc Volume (gal)*	FE (mpg)	CO2 (g)	FE (mpg)**
Baseline	29.64	3.150	9.41	3.042	9.74	24004	10.58
Baseline	29.68	3.166	9.37	3.038	9.77	24184	10.52
Baseline	29.62	3.140	9.43	3.001	9.87	23896	10.63
AVG:		***3.152***	***9.41***	***3.027***	***9.79***	***24028***	***10.57***
Modified	29.68	2.713	10.94	2.627	11.30	21452	11.86
Modified	29.73	2.702	11.00	2.605	11.41	21540	11.83
Modified	29.68	2.738	10.84	2.627	11.30	21463	11.85
AVG:		***2.718***	***10.928***	***2.620***	***11.336***	***21485***	***11.85***
Delta:		***-0.434***	***1.522***	***-0.407***	***1.542***	***-2543***	***1.27***
		-14%	***16%***	***-13%***	***16%***	***-11%***	***12%***

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Observations

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Conclusions- The Derive ECU calibration demonstrates a notable and consistent improvement in fuel consumption over all operating conditions.

Fuel economy/Consumption results demonstrated the following improvements:

- Combined city and highway with minimal idle: **15-17%***
- Combined city and highway with extended idle: **16%**
- Highway: **18-21%***
- Idle: **9%**

**Ranges include data from Plutron and calculated via AFR and mass air flow.*

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