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Evaluation of Emissions from Light Duty Trucks with and without the Use of Gasoline Particulate Filters

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Canada

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Canadian Black Carbon Emissions from the Transportation Sector

Sector	2013	2014	2015	2016	2017
Air Transportation	681	664	671	685	704
Marine Transportation	4 999	5 727	2 635	2 698	2 761
On-Road Transport	7 646	6 958	6 271	6 160	6 171
Diesel	6 784	6 166	5 494	5 349	5 375
Gasoline	862	792	776	811	796
Liquid Petroleum Gas	0.49	0.20	0.15	0.18	0.22
Natural Gas	0.21	0.20	0.20	0.30	0.61
Off-Road Transport	12 604	11 408	10 911	8 389	8 712
Diesel	12 105	10 897	10 405	7 941	8 259
Gasoline, Liquid Petroleum Gas, Natural Gas	499	511	507	448	453
Rail Transportation	1 900	1 762	1 515	1 395	1 404
Transportation and Mobile Equipment (total)	**27 830**	**26 520**	**22 003**	**19 328**	**19 752**
Grand total	**44 313**	**43 222**	**38 487**	**35 548**	**36 309**

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Introduction

- Due to more stringent fuel consumption and emission standards there has been a significant market influx of Gasoline Direct Injection (GDI) vehicles
- GDI vehicles typically have lower fuel consumption but higher Particulate Matter (PM) emissions than Port Fuel Injection (PFI) vehicles
- In order to meet the current Tier 3 and LEV III PM emission standards of 3 mg/mile for Light Duty Vehicles (LDV) and 1 mg/mile by 2025 there is a need for PM control strategies
- Gasoline Particulate Filters (GPF) have a potential of being the primary emission control for PM

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Project Scope

Investigate the benefits of replacing part of the OEM TWC on the emissions of light duty trucks using different GPF configurations, non-catalyzed and catalyzed.

Test Vehicles:

Test Vehicle	PFI_1	GDI_1	GDI_2
Engine	3.6 L Naturally Aspirated	2.7 L Turbocharged	2.7 L Turbocharged
Emission Standard	LDT3 Tier 2 Bin4	LDT3 Tier 2 Bin4	LDT3 Tier 2 Bin4
Test Configuration	Non-catalyzed GPF	Non-catalyzed GPF	Catalyzed GPF
Daily Test Schedule	FTP-75 followed by US06	FTP-75 followed by US06	FTP-75 followed by US06

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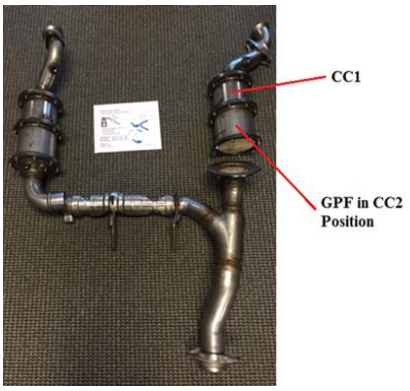
Project Scope



GPF Specifications:

GPF System	Non-catalyzed	Catalyzed
Sample Size	Ø5.2 in×5 in	Ø5.66 in×4.92 in
Porosity	~ 55%	~ 65%
Material	Cordierite	Cordierite
Cell Design	200 cpsi / 8 mil	300 cpsi / 8 mil

*The Platinum Group Metal (PGM) coating was consistent with the OEM CC2 function of GDI_2.

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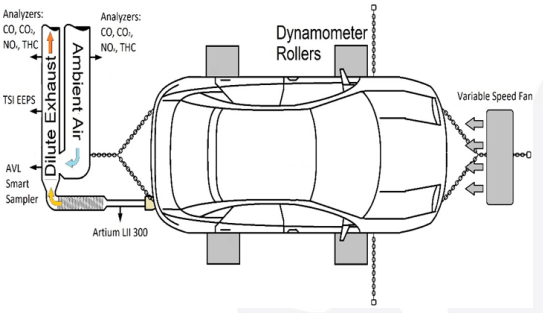
Project Scope

- The vehicles were tested on a four wheel drive chassis dynamometer at 25 °C & -7 °C.
- PFI_1 and GDI_1 were tested in stock OEM configuration and with a non-catalyzed GPF installed.
- GDI_2 was tested in stock configuration in addition to catalyzed GPF configuration.
- GDI_2 was also tested on-road using Portable Emissions Measurement System (PEMS)
- Tier 3 E10 certification fuel was used.



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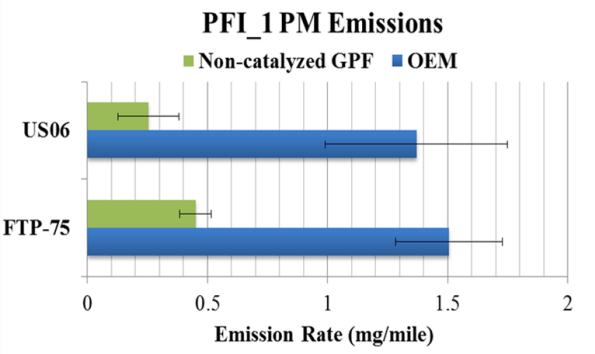
PFI_1 Particulate Matter Results



- 70.1% reduction in PM for the FTP-75 and 82% for the US06

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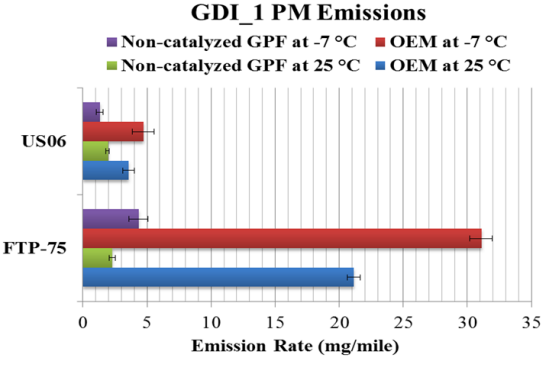
GDI_1 Particulate Matter Results



FTP-75:
- 89% decrease at 25 °C
- 86% decrease at -7 °C

US06:
- 46% decrease at 25 °C
- 72% decrease at -7 °C

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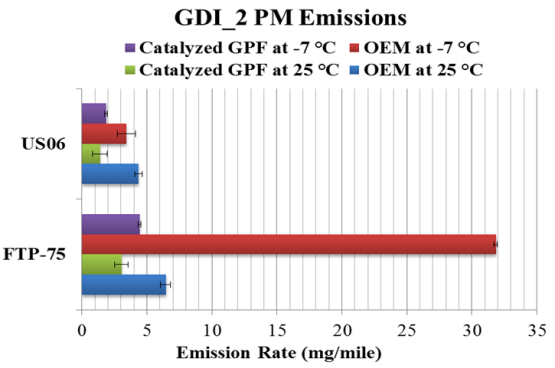
GDI_2 Particulate Matter Results



FTP-75:
- 53% decrease at 25 °C
- 86% decrease at -7 °C

US06:
- 69% decrease at 25 °C
- 46% decrease at -7 °C

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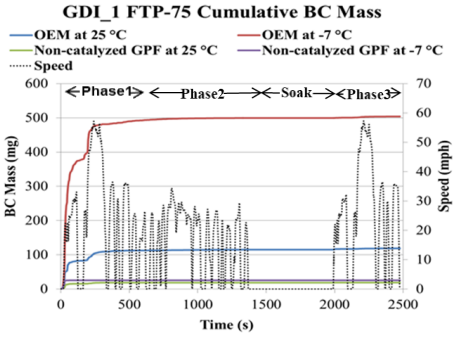
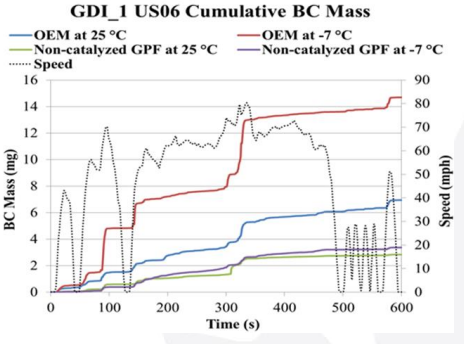
GDI_1 Cumulative Black Carbon Mass





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Filtration Efficiency Based on Black Carbon Mass

Vehicle	Test	Temperature (°C)	BC Filtration Efficiency (%)
PFI_1*	FTP75	25	79
	US06	25	96
GDI_1*	FTP75	25	84
	FTP75	-7	95
	US06	25	59
	US06	-7	77
GDI_2*	FTP75	25	64
	FTP75	-7	90
	US06	25	27
	US06	-7	48

*PFI_1 and GDI_1 were tested with a non-catalyzed GPF and GDI_2 was tested with a catalyzed GPF

Filtration efficiency overall lower with catalyzed GPF on GDI_2

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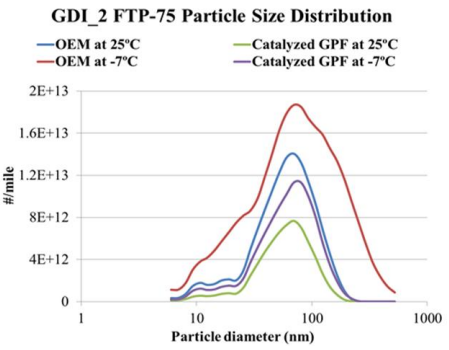
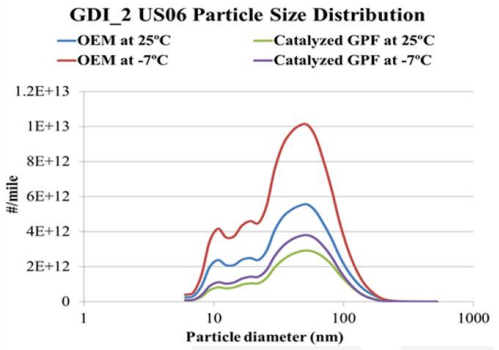
GDI_2 Particle Size Distribution





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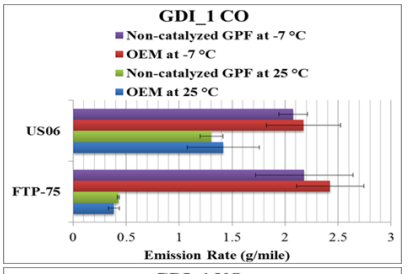
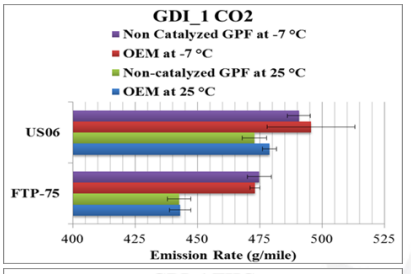
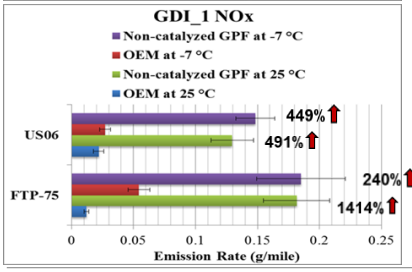
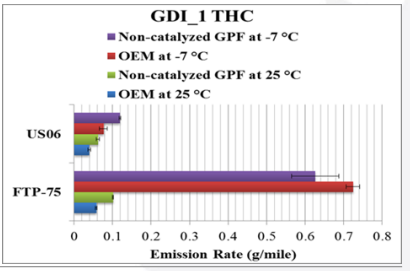
GDI_1 Gaseous Results









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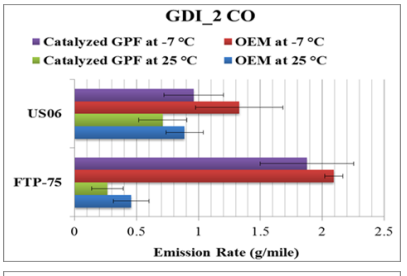
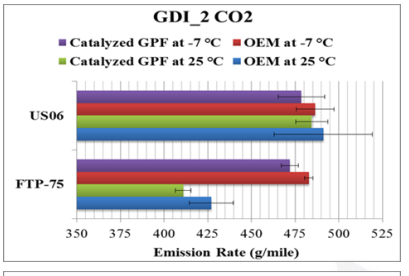
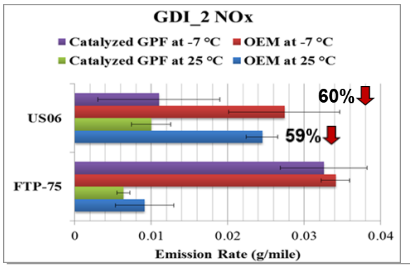
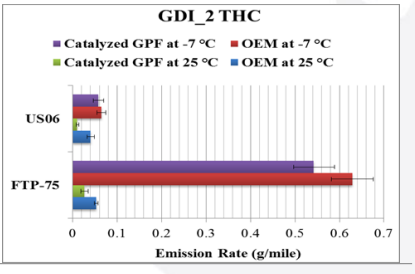
GDI_2 Gaseous Results









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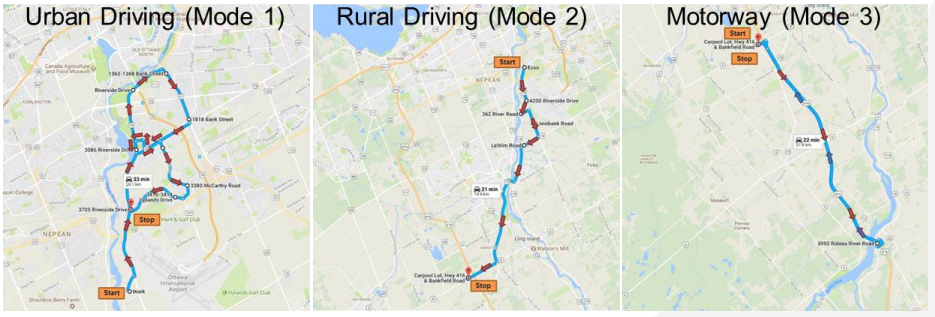
On-road RDE Testing Route

The on-road tests consisted of a driving route that combined three different driving segments and was compliant with Act III of the European Union RDE regulations outlined in EURO VI. Three modes represented different driving patterns:



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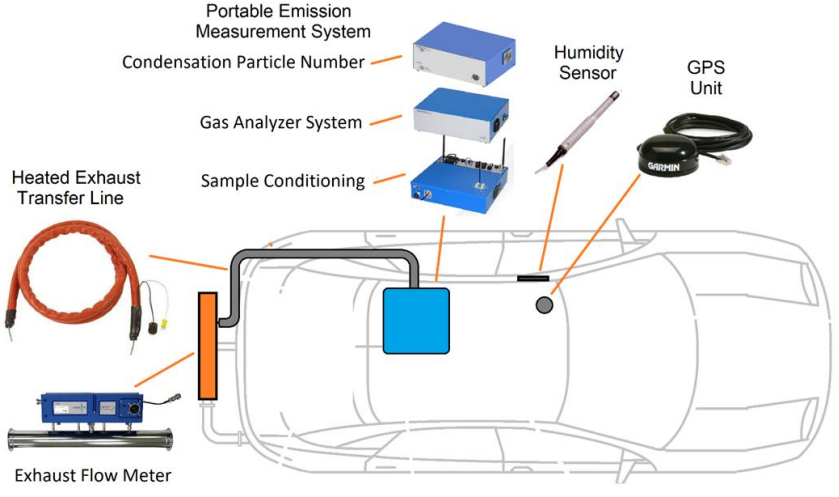
On-road RDE Testing Setup



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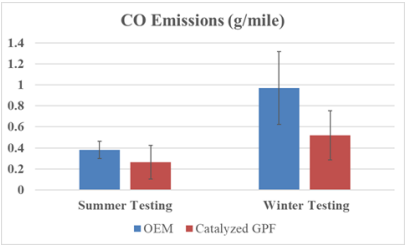
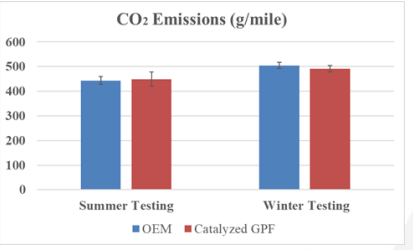
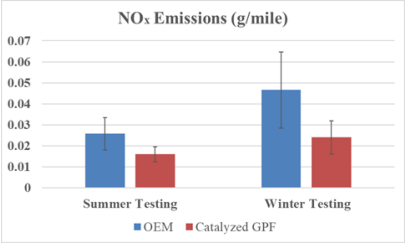
On-road Gaseous Emissions







No significant difference in gaseous emissions between OEM and catalyzed GPF configurations

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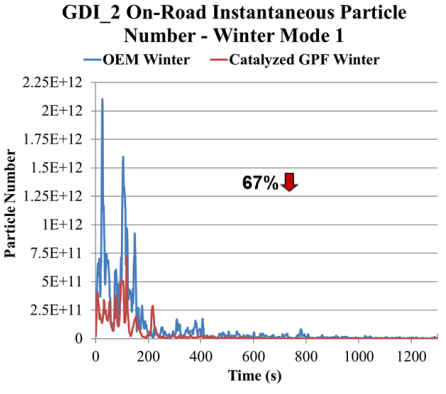
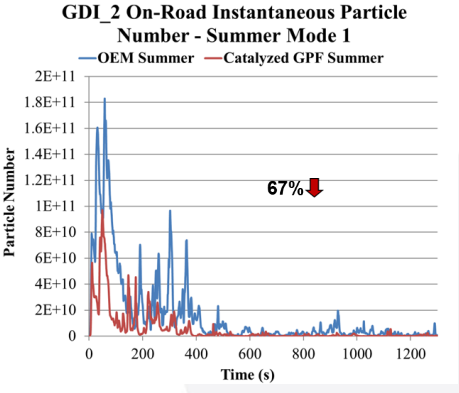
On-road Particle Number Emissions





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Conclusions

GPF System	Non-catalyzed	Catalyzed
Observations	• Higher overall filtration efficiency	• No need for additional gaseous conversion strategies • More holistic solution due to its dual function
Challenges	• Reduced gaseous conversion • Need additional gaseous solution potentially added catalyst upstream of GPF	• Short term filtration challenges which can be investigated by additional testing following mileage accumulation with GPF installed • Other factors to consider like price of PGM coating and more OBD controls

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Questions?

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