Durability Experience with Electronic Controlled CNG and LPG Engines

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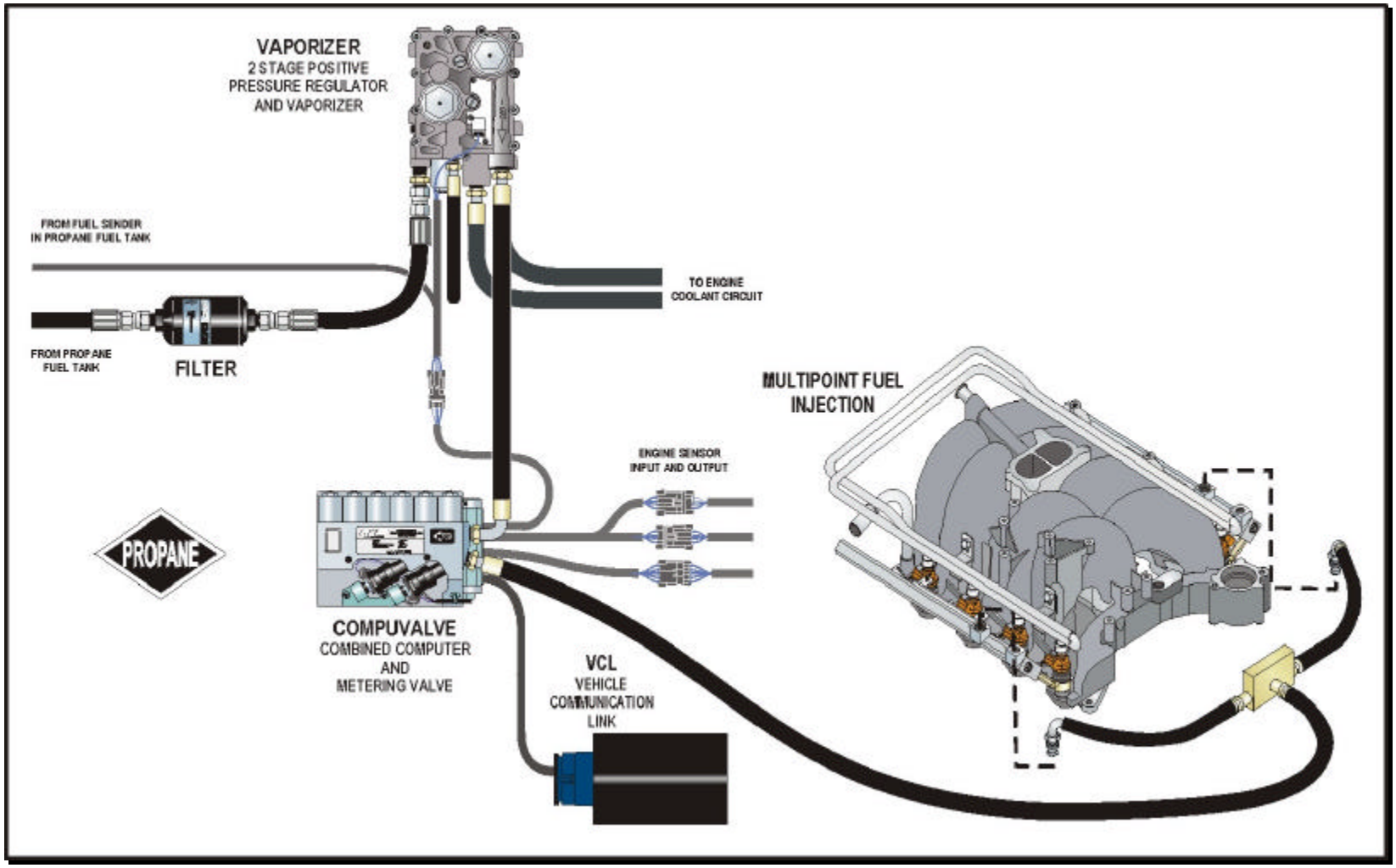
GFI SYSTEM DURABILITY EXPERIENCE

- CNG Vehicles
  - 50,000 Miles Emissions Durability
- Heavy Duty CNG AND LPG Engines
  - Up To 2000 Hours Engine Emissions Durability Testing

PROPANE SYSTEM



MY 1999-2000 BI-FUEL GFI-FORD ALLIANCE PRODUCT PLANS

• LPG 5.4L GFP F-Series Trucks	ULEV
• CNG 5.4L GFP F-Series Trucks	ULEV
• LPG 5.4L GFP E-Series Vans	LEV
• CNG 5.4L GFP E-Series Vans	LEV
• CNG 2.0L GFP Contour Passenger Car	TLEV
• LPG 6.8L V10 Chassis Cab Incomplete Vehicle	ULEV

VEHICLE EMISSIONS DURABILITY COMPARISON OF GFI AND OEM SYSTEMS LIGHT DUTY CNG TRUCKS

50K MILE MULTIPLICATIVE EMISSIONS DFs

Vehicle Type	NMHC	CO	NOx
Bi-Fuel CNG	1.78	1.00	1.15
Converted Gasoline	1.56	1.00	1.20
Standard Gasoline	1.66	1.24	1.29

Mileage accumulated 50,000 miles on a test track

ENGINE EMISSIONS DURABILITY HEAVY DUTY CNG ON HIGHWAY

CNG MULTIPLICATIVE EMISSIONS DFs

Durability Period	NMHC	THC	CO	NOx
Actual 2000 hours	2.04	1.84	1.82	1.92
Projected 5000 hours	3.70	3.19	3.14	3.40

200 HP gasoline engine with standard TWC, converted to GFI closed loop electronic CNG
2000 hrs durability test schedule yielding 50% load factor, full range of speeds and loads
Emission tests, EPA transient emissions test procedure every 300 hrs from 125-2000 hr
Emission DFs calculated by linear regression

ENGINE EMISSIONS DURABILITY HEAVY DUTY LPG ON HIGHWAY

LPG MULTIPLICATIVE EMISSIONS DFs

Durability Period	NMHC	THC	CO	NOx
Projected 2000 hours	4.55	3.25	1.27	2.47
Projected 5000 hours	10.23	6.86	1.70	4.83

300 HP gasoline engine with standard TWC, converted to GFI closed loop electronic LPG
500 hrs durability test schedule provided by the OEM.
Emission tests, EPA transient emissions test procedure every 100 hrs from 125-500 hrs
Emission DFs calculated by linear regression, projected to 2000 hrs

ESTIMATED USEFUL LIFE EMISSIONS FROM CARB TEST ENGINES USING LPG PROJECTED 5000 HR DFs

Emissions in g/bhp.hr; Multiplicative Emissons DFs

Description	NMHC	CO	NOx	NMHC+NOx
Projected LPG Mult. 5000 hr DFs	10.23	1.70	4.80	
CARB LPG TWC Test Engine* 0 hr. Controlled Emissions	0.09	2.1	0.01	0.1
Useful Life emiss. Engine 1	0.9207	3.57	0.048	0.9687
2004 MY emiss. Standards		37		3

* CARB Mail Out MSC 98.20

USEFUL LIFE EMISSIONS FROM A GFI INDUSTRIAL ENGINE

Emissions in g/bhp.hr; Multiplicative Emissons DFs

Description	NMHC	CO	NOx	NMHC+NOx
GFI LPG Industrial engine Controlled Emissions at 0 hours.	0.044	1.309	0.015	0.059
5000 hr Emissions DFs	10.23	1.7	4.8	NA
GFI LPG Industrial engine Useful Life emissions	0.45	2.23	0.07	0.52
2004 MY emiss. Standards		37		3.0

CONCLUSIONS

- LPG and CNG Emissions DFs Have Been Generated Which Are Considered Representative, or Worst Case Values for Off-Highway Applications
- These DFs Appear To Be Much Higher Than What CARB Has Been Considering, Which May Be Based on Lower Mileage Automotive Experience
- Application of the Higher DFs to a Common Industrial LPG Engine Still Meets the 2004 Standards
- An Off-Road LPG and CNG Fuel Specification Will Be Required to Guarantee Useful Life Emissions Performance