Japan Clean Air Program (JCAP)

Step Ⅰ Study of Gasoline Vehicle and Fuel Influence on Emissions

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Objective

- Provide current emission technology data for the air quality model with the current vehicle/ current fuel.
- Provide the scientific data for the future fuel / vehicle regulation.
- Obtain the emission data with combination of advanced vehicle and fuel technologies.

Japanese Petrol Market

- Catalyst for the passenger car since `78
- Sulfur level of gasoline kept as low as 30ppm average since `78
- New technology such as lean burn and direct injection gasoline engine and NOx storage reduction catalyst have been developed and marketed under these back ground

Gasoline Emission test Matrix (STEP I)

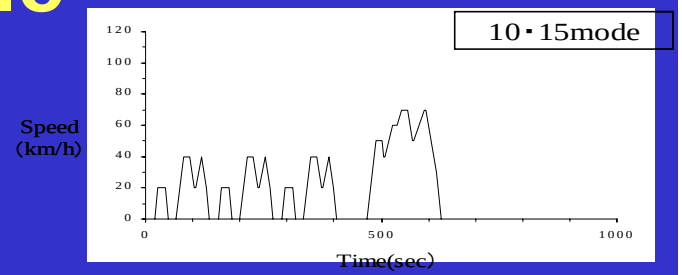
Test Vehicle	19 vehicles (15 current, 3 prototype, 1 LEV)		
Test Fuel		Tail-pipe	Evaporative
	RVP KPa	75 → 55	75 → 55
	Aromatics vol.%	37 → 22	N/A
	Sulfur ppm	96 → 22	N/A
	Benzene vol.%	3.2 → 0.8	N/A
Test Mode		10－15Mode 11Mode	SHED (HSL,DBL,RL)

TEST Vehicles

1. Wide variety of vehicles are tested from motorcycle, mini(0.65L) to 3L

2. Gasoline direct injection and lean-burn engine included

3. As a reference LEV is tested at the Japanese driving cycle



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Gasoline Emission test Matrix

		Vehicles		FUEL	Measure
STEP I	Current	PFI(Stoic) + TWC	9	RVP :55-75 (Kpa) Aroma :20-40 (Vol%) Sulfur :30-100 (ppm) Bz :1.0-3.0 (Vol.%) RFG II (Refer.)	Tail Pipe (10-15 & 11Mode) CO THC NOx CO2 CH4 Benzene 1-3,Butadiene B(a)p Formaldehyde Acetaldehyde NO2 NO Evaporative HSL DBL RNL
		PFI(Lean) + TWC	1		
		PFI(Lean) + de-NOx	1		
		DFI (Lean) + de-NOx	1		
		DFI (Lean) + TWC + de-NOx	1		
	Interim 2000-	PFI (Stoic) + TWC	3		
		LEV (Reference)	1		
STEP II	Future 2005-	DFI (Lean) + de-NOx	3	Sulfur:10-80 (ppm) + TBD	
		PFI(Stoic) + TWC	1		
		+ TBD			

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TEST Vehicles

		Vehicle Class		Emission System		
		Class	cc	Carb	Cat	VIN.
Current Vehicle	PV	Mini	660	MPI-S	C - 3 -Pd/Rd	GV50
		S	1000	MPI-S	C - 3 -Pd	GV51
			1500	MPI-S	C - 3 -Pd/Rd	GV03
				MPI-L	U - 3 -Pt/Pd/Rd	GV52
			1800	MPI-L	U - L -Pt/Rd	GV06
			2000	MPI-S	U - 3 -Pt/Rd	GV01
				DFI-L	C/U- 3 -Pt/Pd/Rd	GV53
		M	1800	MPI-S	U - 3 -Pt/Pd/Rd	GV08
				DFI-L	U - 3 -Pt/Rd	GV07
			2500	MPI-S	U - 3 -Pd/Rd	GV02
			3000	MPI-S	U - 3 -Pd	GV54
	Truck	Mini	660	MPI-S	C - 3 -Pd/Rd	GV55
				MPI-S	U - 3 -Pt/Rd	GV04
	Motorcycle		50	Carb-S		GM02
			250	Carb-S		GM01
Model LEV	PV	S	1600	MPI-S	C - 3 -Pt/Pd/Rd	GV60
		M	2200	MPI-S	C/U- 3 -Pt/Rd	GV05
			3000	MPI-S	C/U- 3 -Pt/Pd/Rd	GV61
			3000	MPI-S	U - 3 -Pd	GV70

1.Wide variety of vehicles are tested Mini to motorcycle

2.Gasoline direct injection and lean-burn engine included

3. As a reference LEV is tested with the Japanese fuel and driving cycle

Regent

MPI: Multi-point Injection
DFI: Direct Fuel Injection
-S: Stoichiometric
-L: Lean
C: Closed copule
U: Under Floor
3: 3way-catalyser
L: Lean-NOx catalyser

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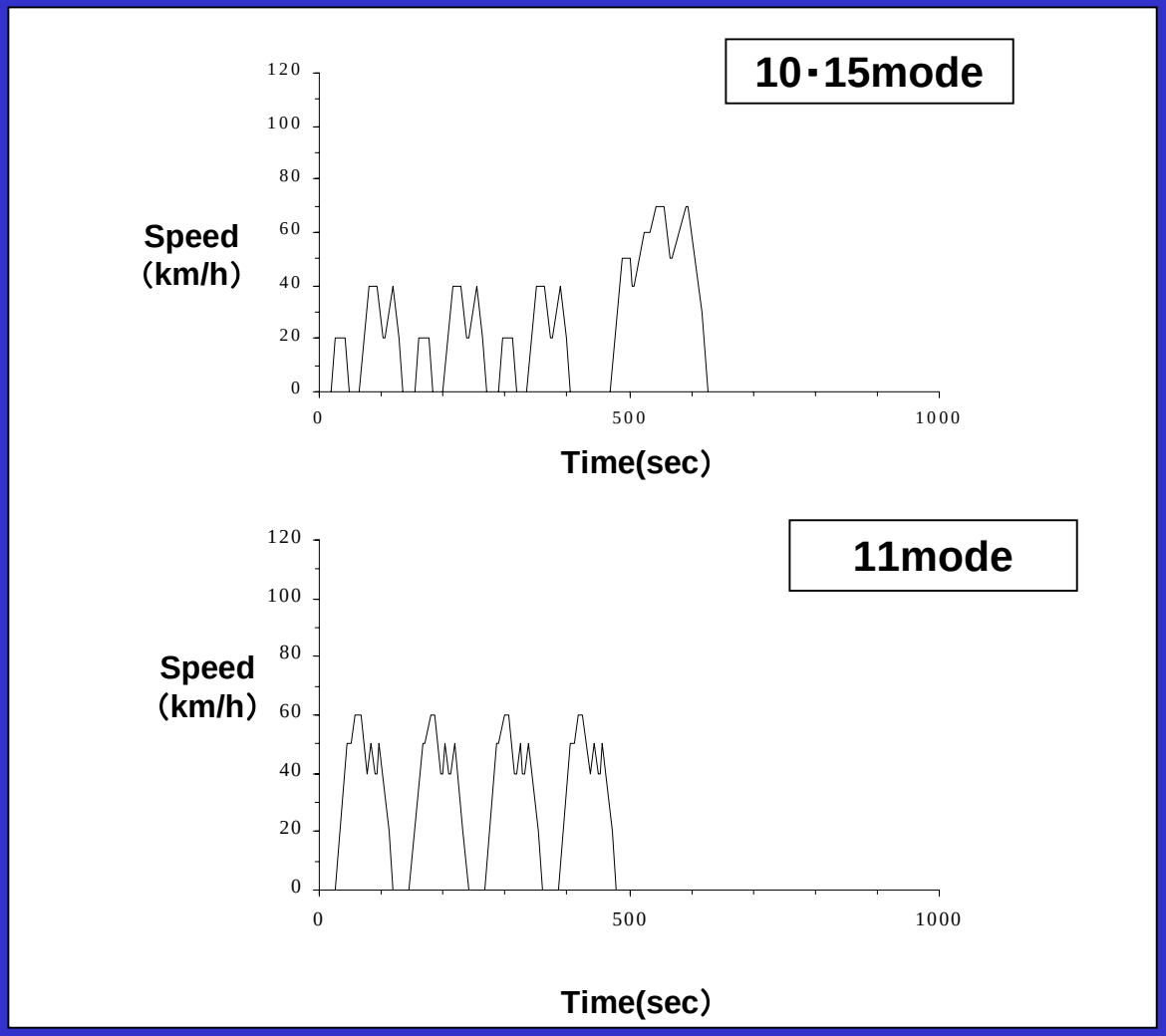
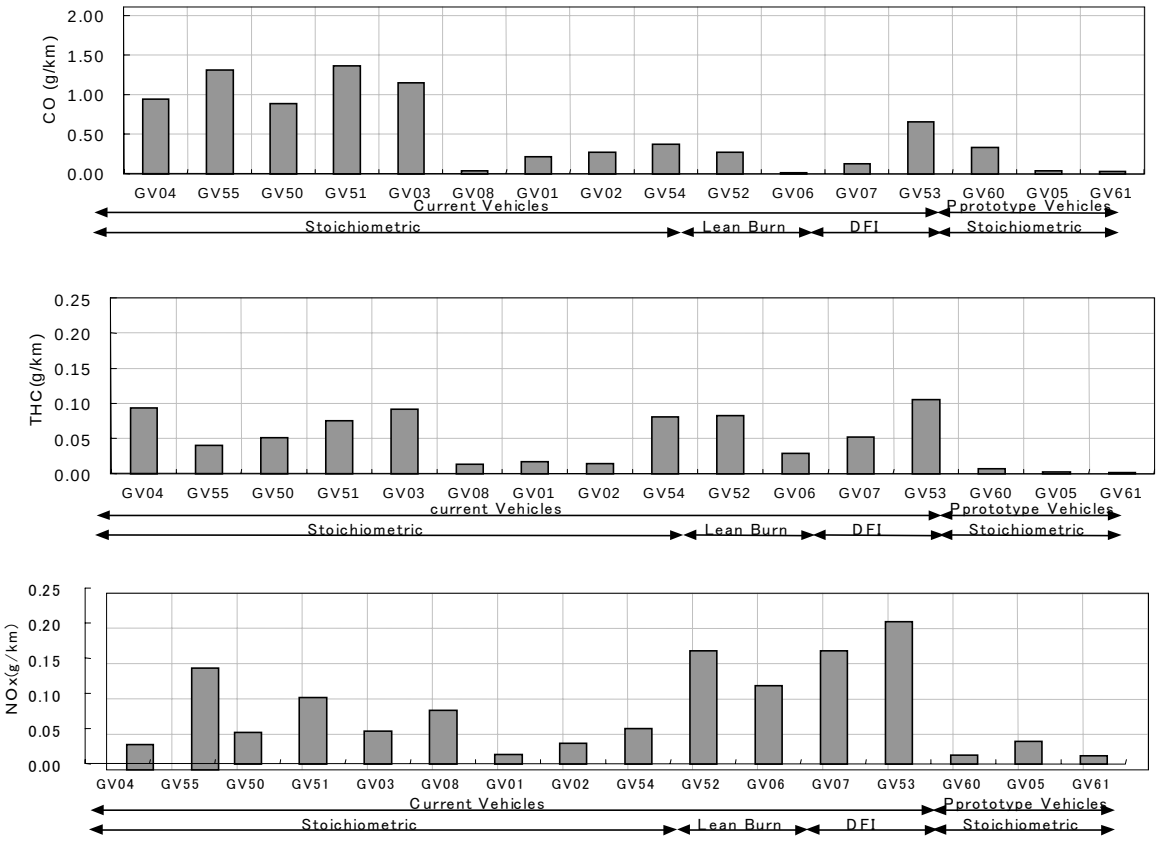
Key Issues

- Emission characteristics of vehicle technologies
- How much fuel property influence for new technologies?
- Do we still need to cut sulfur from current low level?
- How behave unregulated emission by reduction of emission?

Japanese Driving Cycle for Emission Test

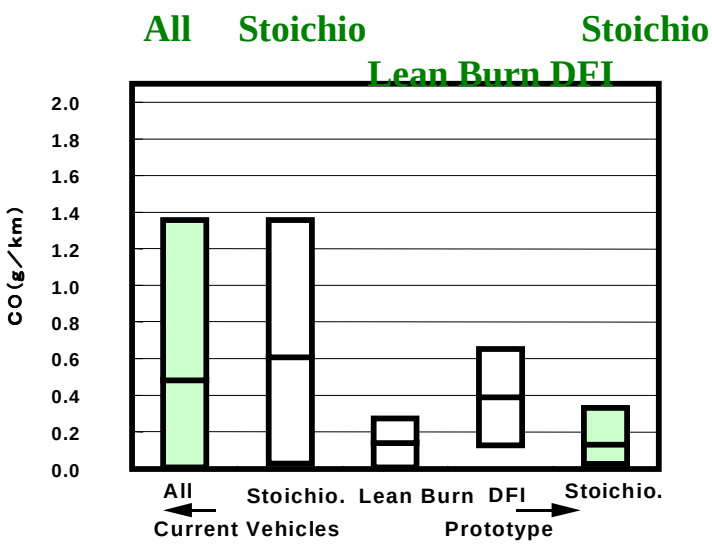


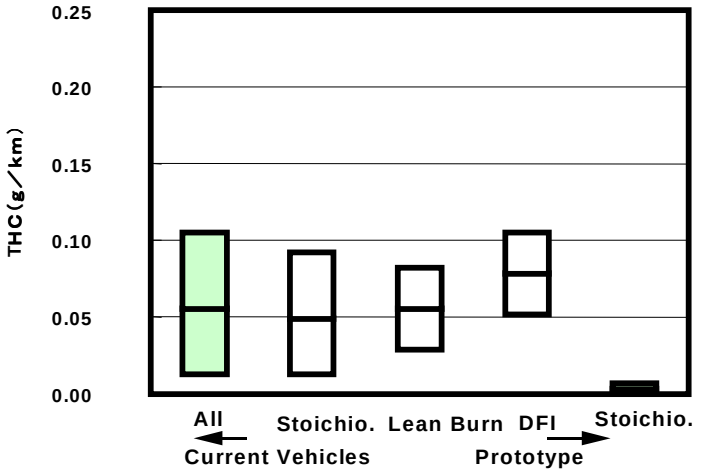
Emission variation 10-15mode

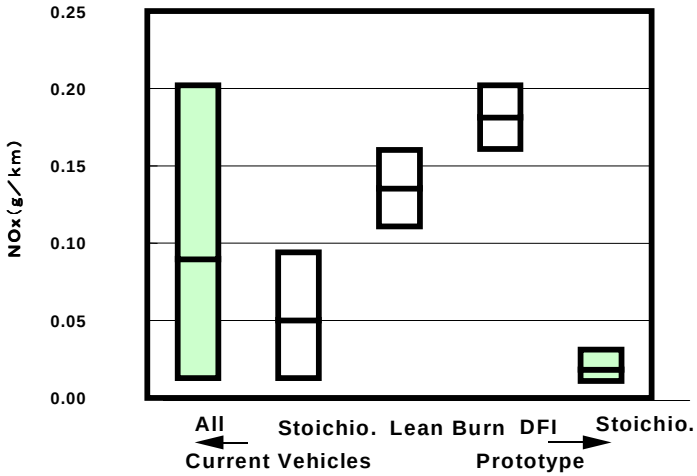


Current Vehicles **Proto Type Vehicles**

Emission characteristics 10-15mode





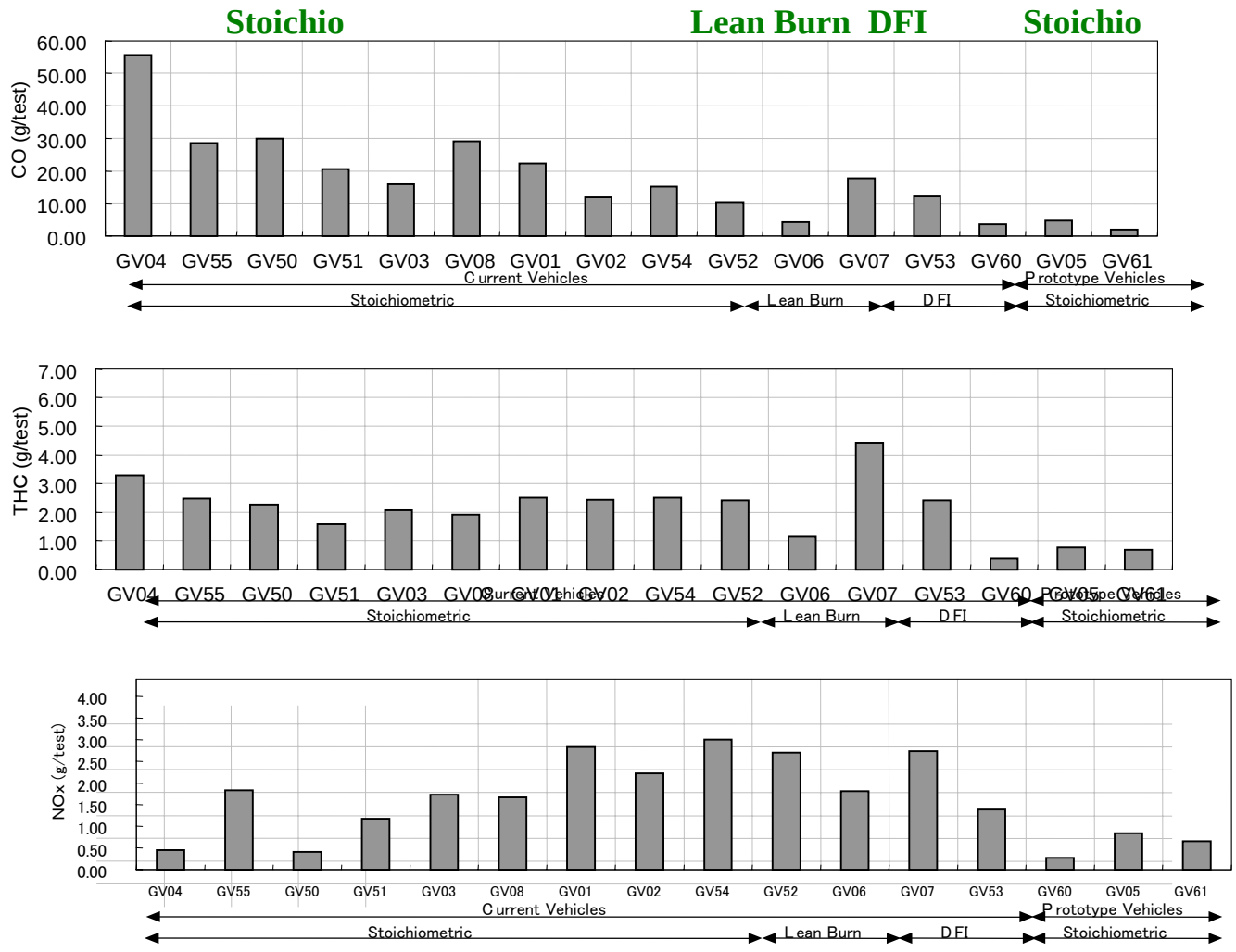


Explanation of Charts:
- Maximum value on Y axis : '78 Regulation
- Interpretation of bars

Data variation ← Average

Number of test vehicles
- Current vehicles : Stoichiometric 7
  Lean Burn 4
  DFI 2
- Prototype vehicles: Stoichiometric 3

Emission variation 11-Mode



SAE2000 Fig. 3 Emissions Levels of Test Vehicles with Market Average Fuel（11 Mode）

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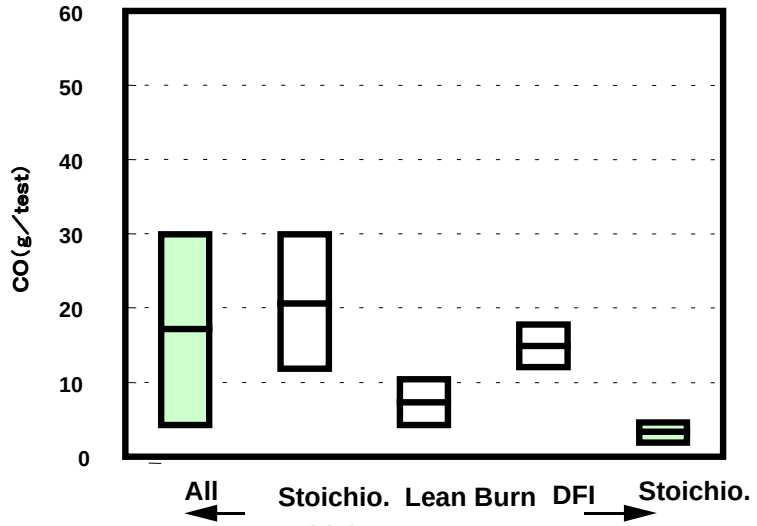
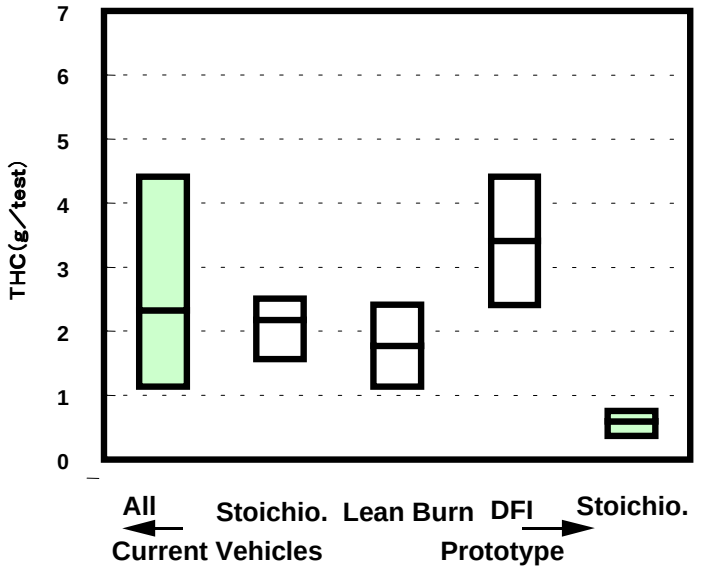
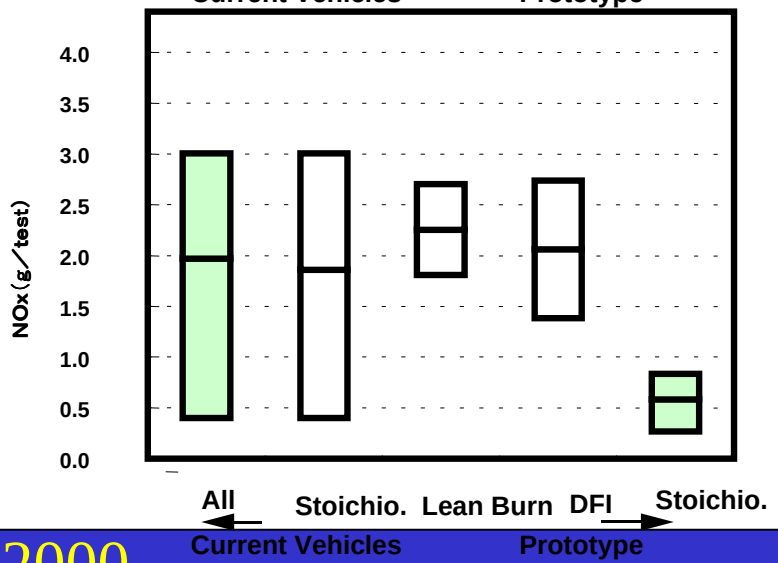
Emission characteristics 11-mode







Explanation of Charts:
- Maximum value on Y axis : '78 Regulation
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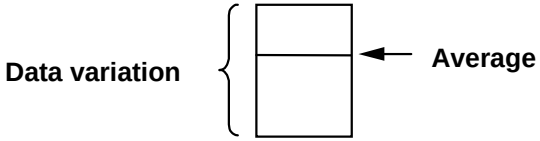

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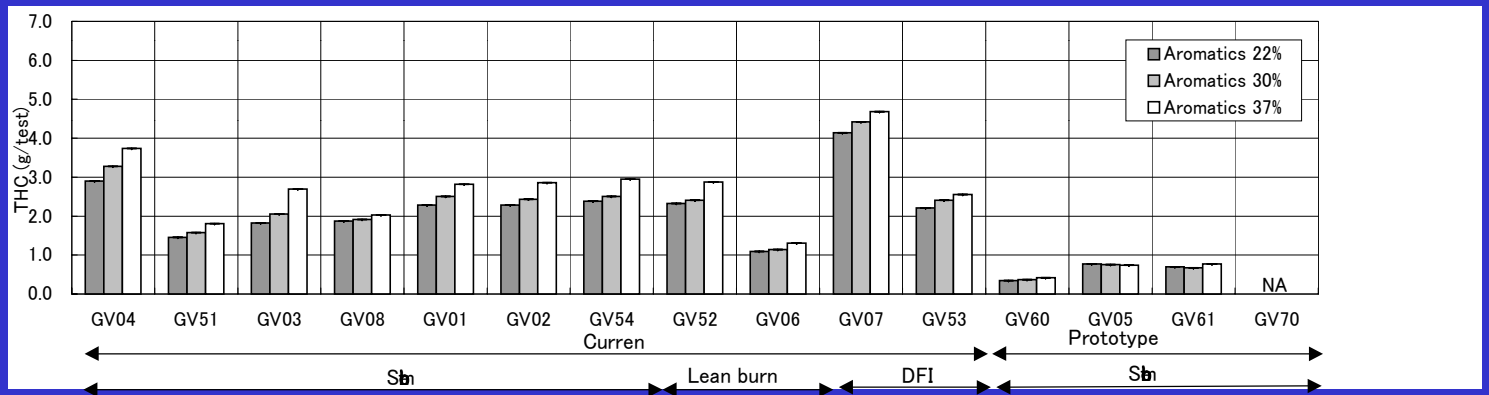
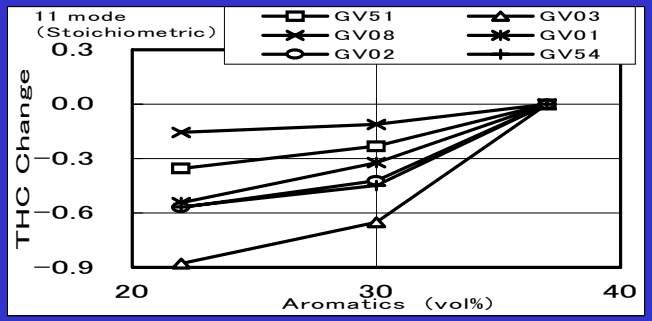
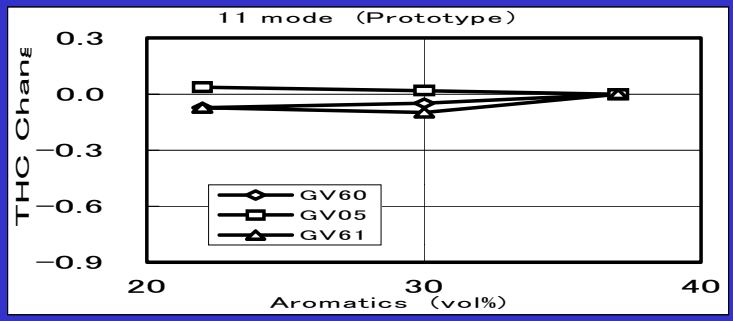
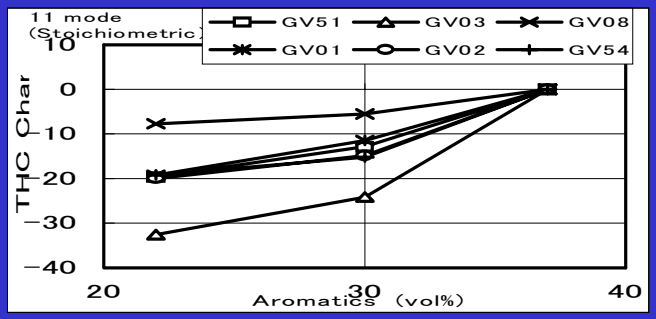
  Lean Burn 4
  DFI 2
- Prototype vehicles: Stoichiometric 3

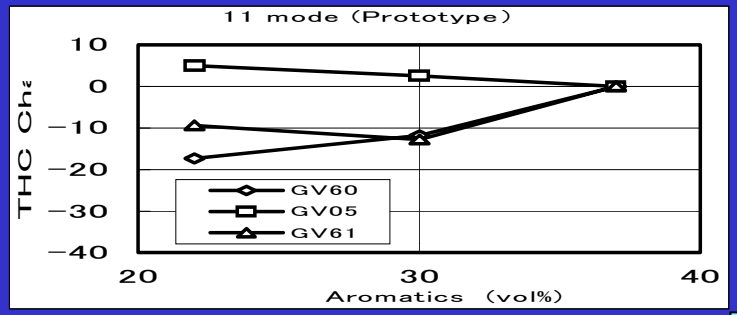
Effect of Aromatics on 11-mode THC











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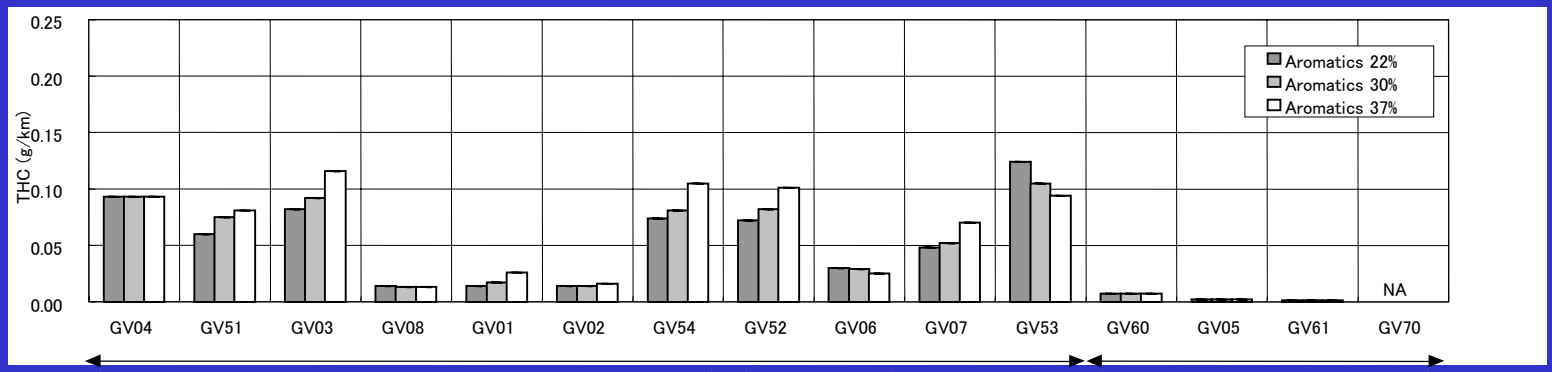
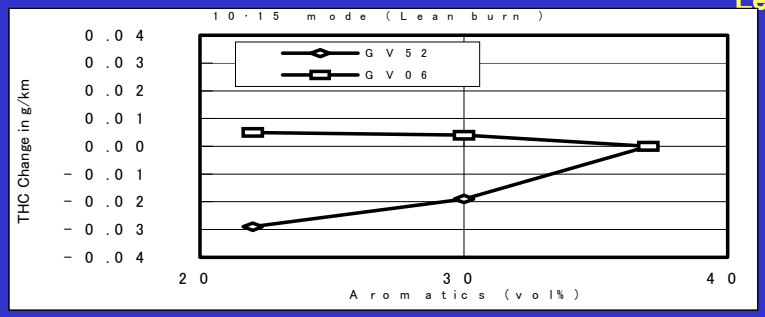
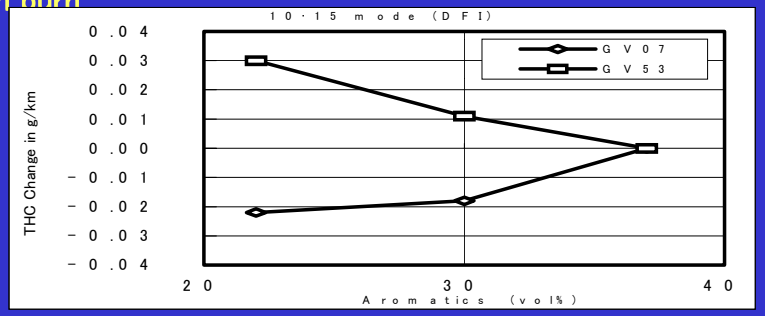
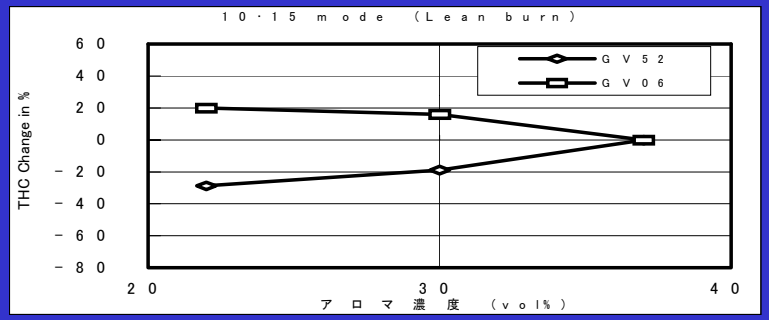
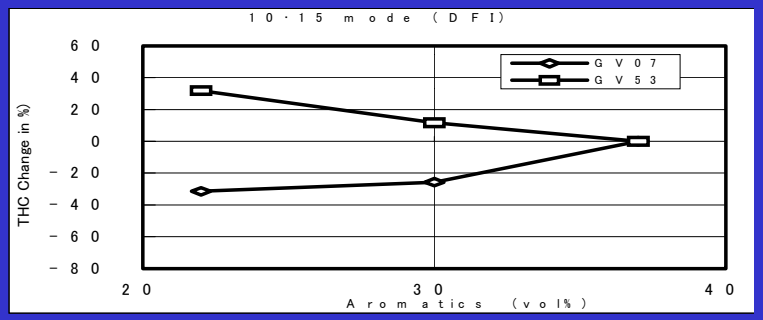
Effects of Aromatics on Emissions (10·15 mode THC)











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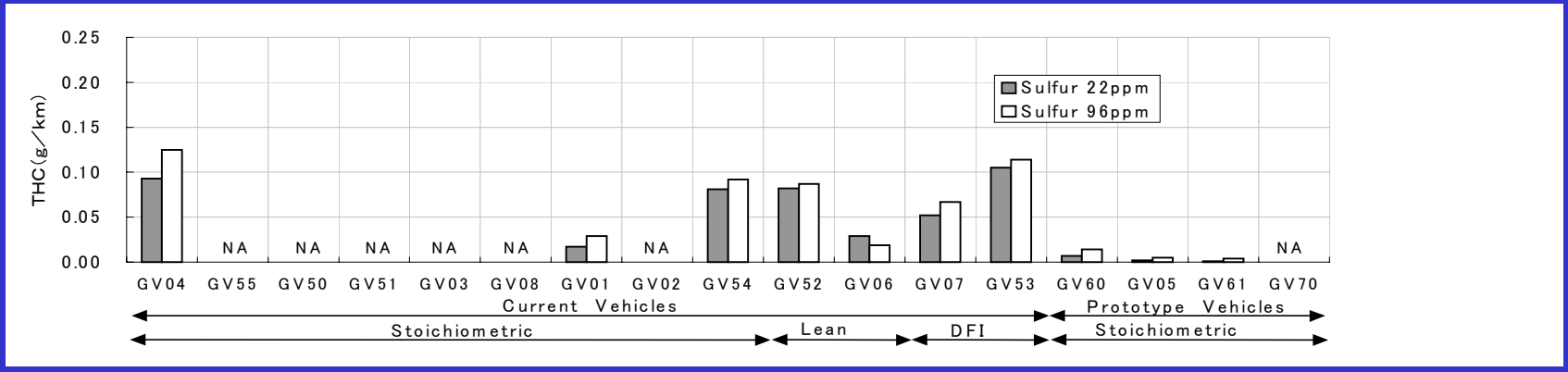
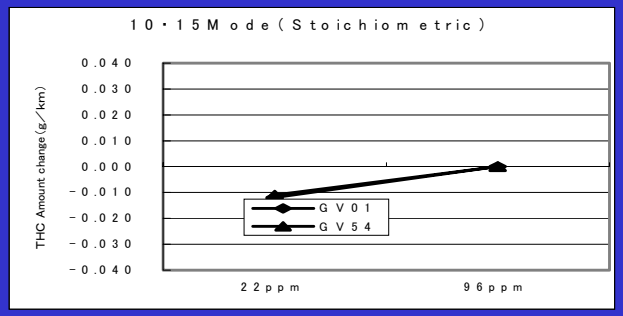
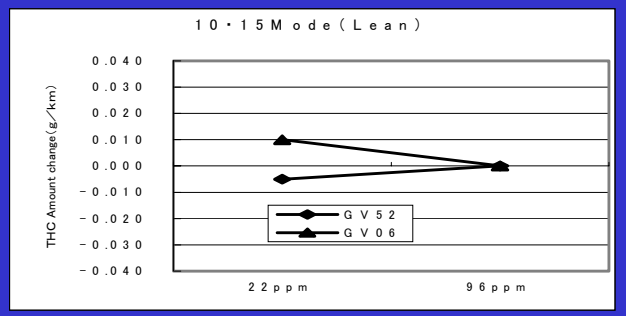
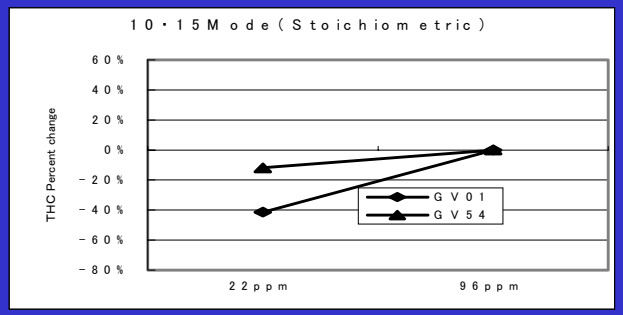
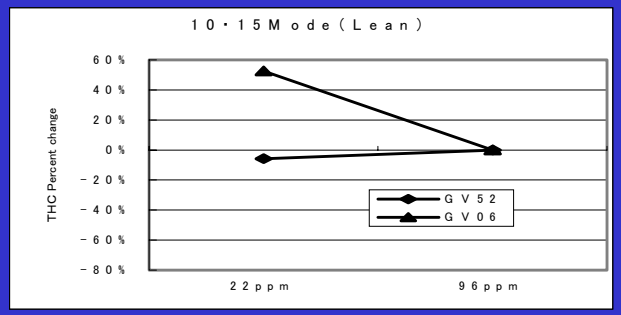
Effects of Sulfur on Emissions (10·15mode THC)











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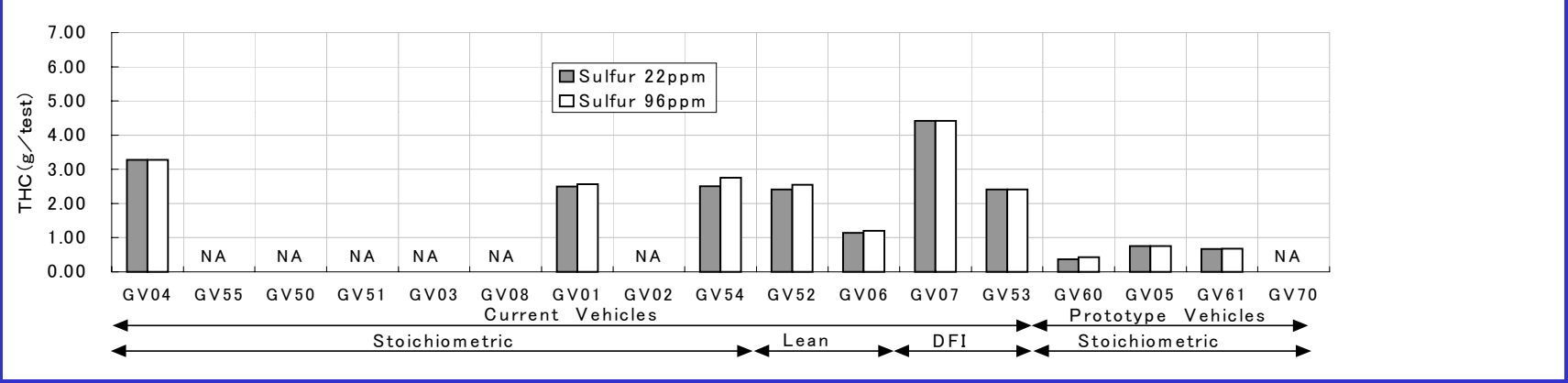
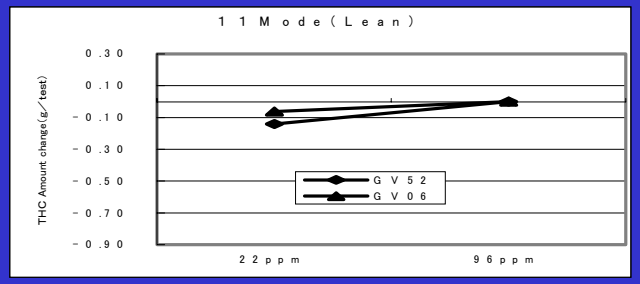
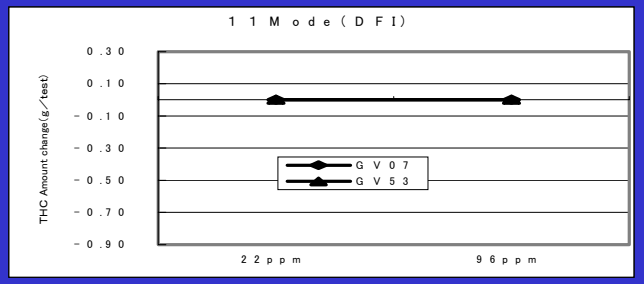
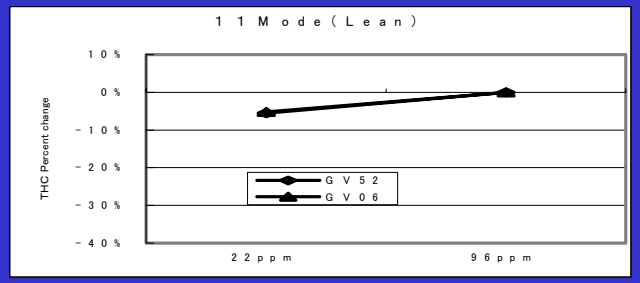
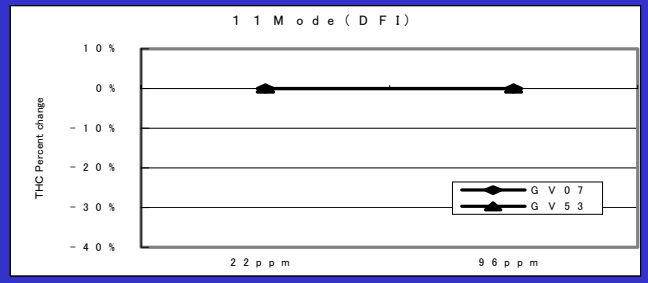
Effects of Sulfur on Emissions (11mode THC)











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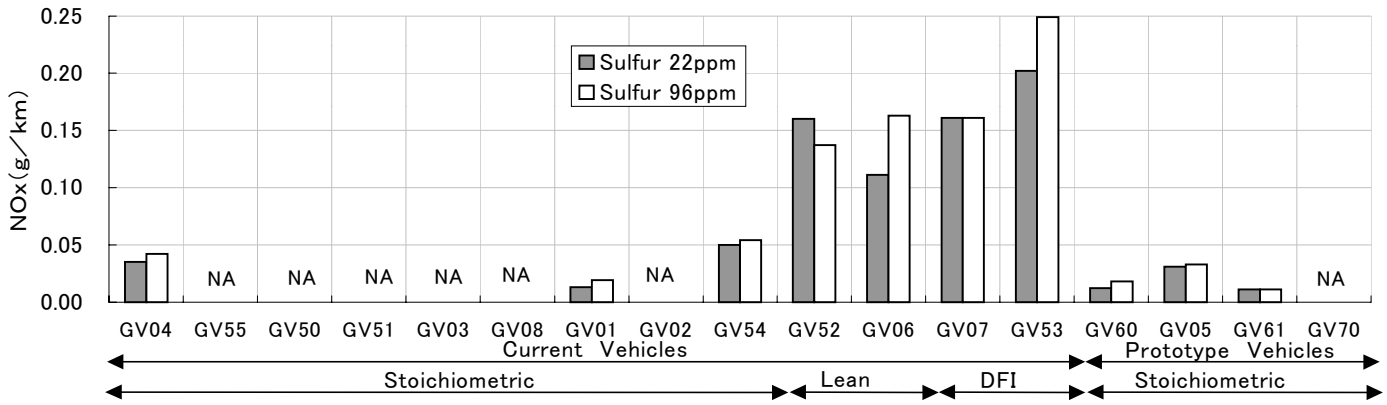
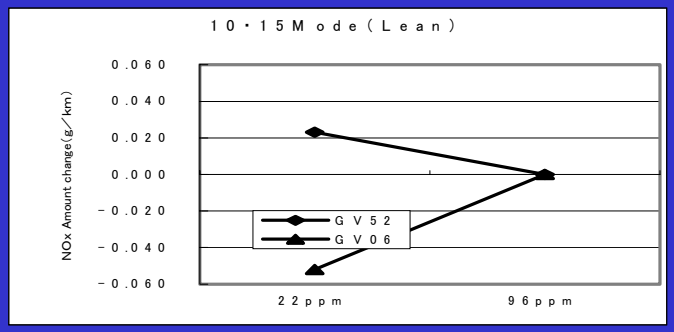
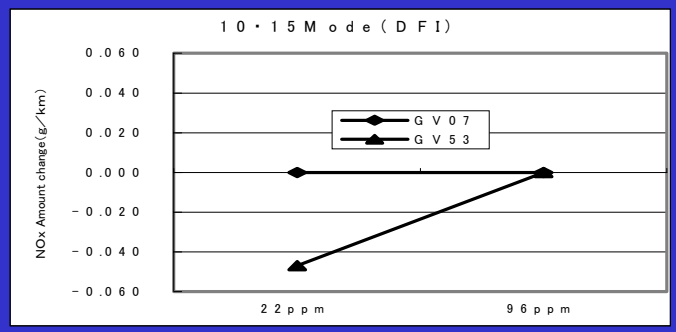
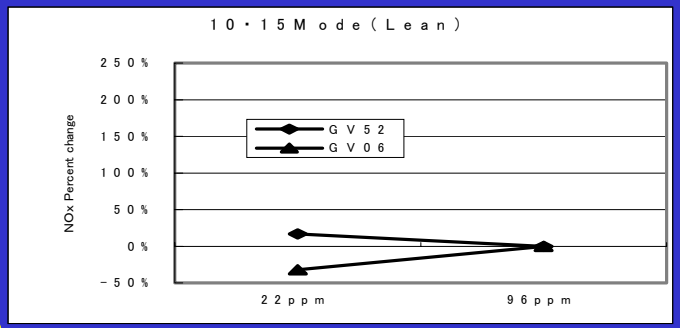
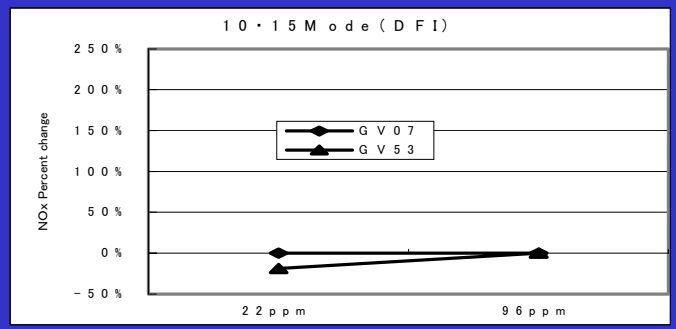
Effects of Sulfur on Emissions (10·15mode Nox)











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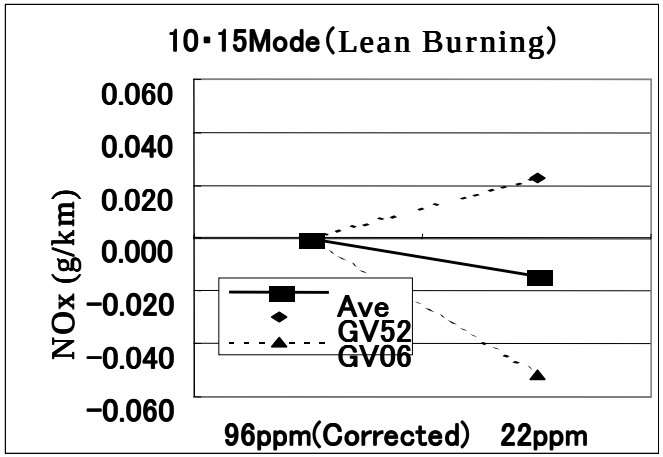
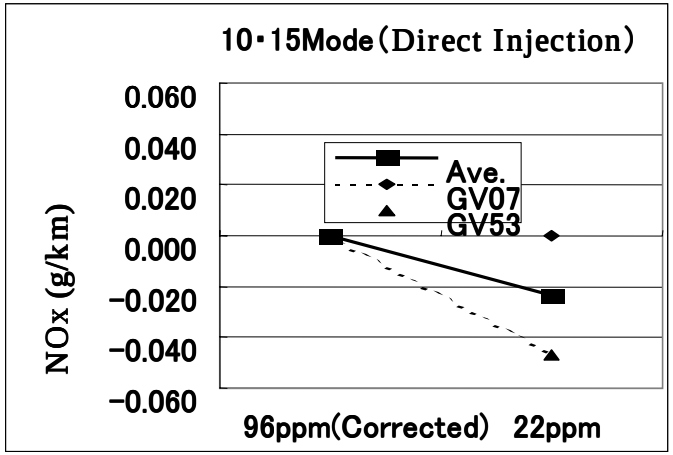
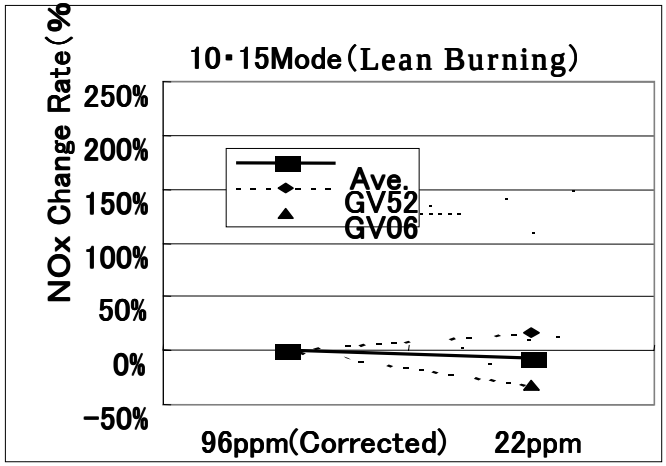
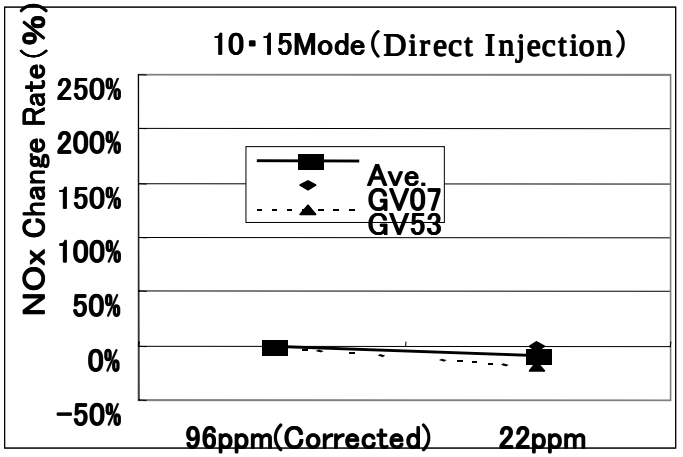
Effects of Sulfur on Direct-Injection and Lean Burn Engines (10・15 Mode NOx)

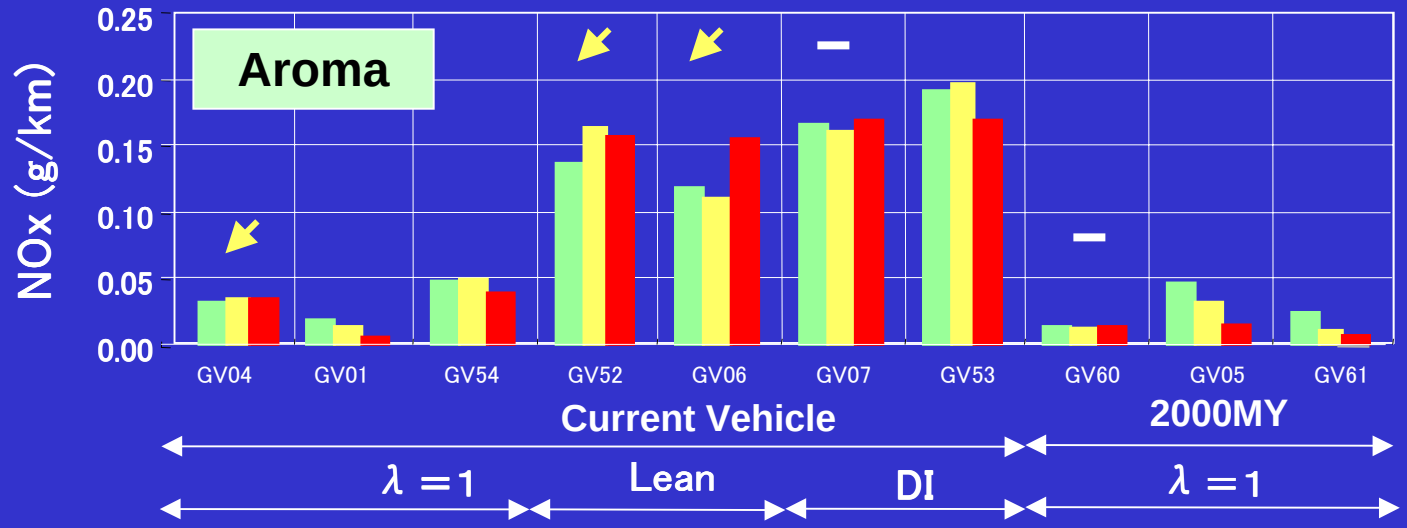






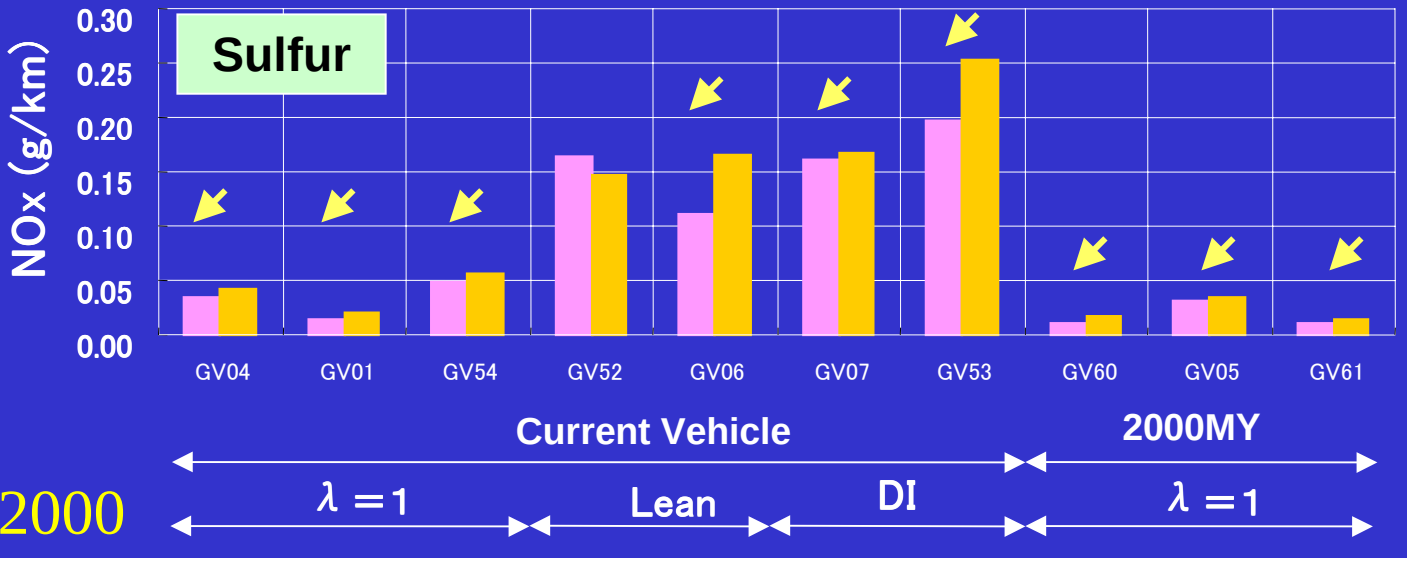


Gasoline Tail-pipe EM (Influence of Aroma. and Sulfur)



10-15mode

- Aroma 22%
- Aroma 30%
- Aroma 37%



10-15mode

- Sulfur22ppm
- Sulfur96ppm

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Gasoline Emission test Results

- Within the current vehicles,

  Direct injection Engine emits more HC in cold and NOx in hot

  Lean-burn Engine emits more HC in cold

  than that of Milti-points Injection engine

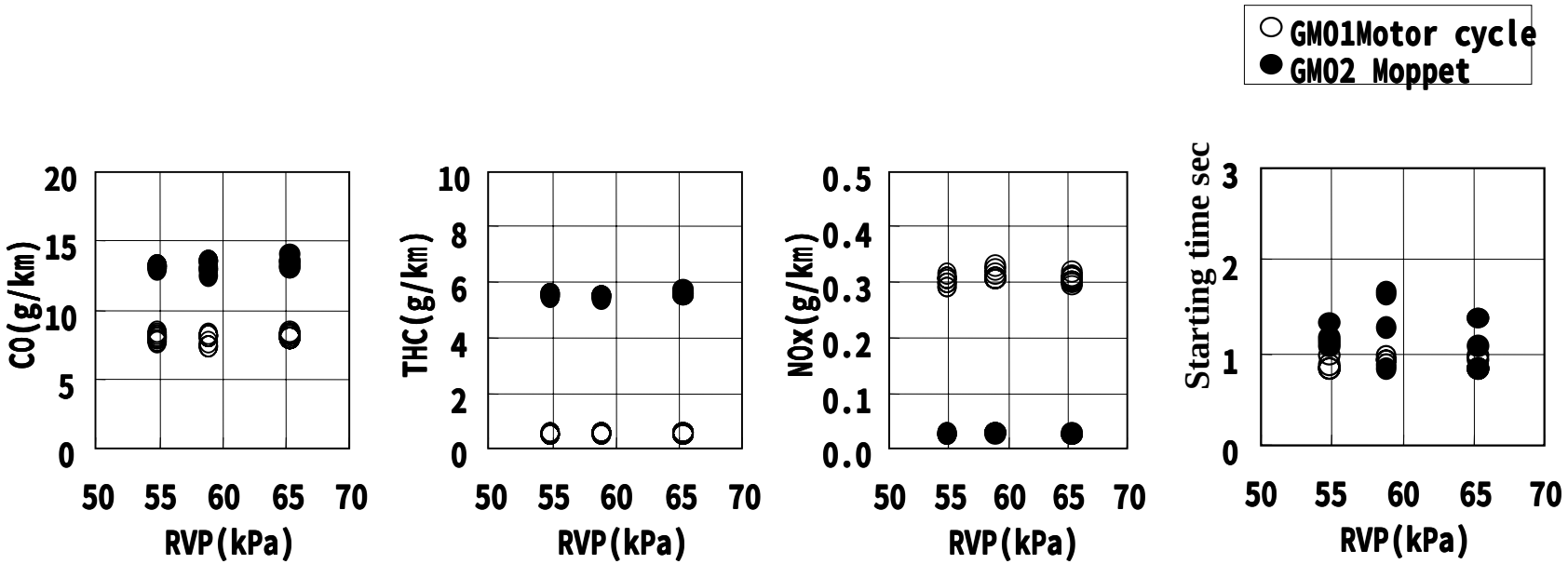
- Reduction of aromatic and Sulfur content in Gasoline are generally effective to reduce exhaust emissions.

Reduction Aroma.	Hot-Start Mode(10-15mode)	CO ↘ THC ↘ NOx ↗
	Cold-start mode (11mode)	CO ↘ THC ↘ NOx ↘
Reduction Sulfur	Hot-Start Mode(10-15mode)	CO ↘ THC ↘ NOx ↘
	Cold-start mode (11mode)	CO ↗ THC ↘ NOx ↘

Evaporative Emission (STEP I)

Fuel Property	Test Mode	Emission Result		Results of Existing Data Analysis
		Current Vehicle	Prototype Vehicle	
RVP 75 → 55KPa	HSL	No Tendency	No Tendency Canister weight Decrease	Decrease
	DBL	Decrease	No Tendency Canister weight Decrease	Decrease
	RNL	Decrease	Depends on vehicles	Decrease

Emissions of Motor cycles



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Gasoline Tail-pipe Emission (STEP I)

↗ : Increase ↘ : Decrease : Depends

Fuel Property	Test Mode	Emission Results / Existing Data		
		CO	HC	NOx
Aromatic Contents 37 → 22 vol.%	11:cold	↗ / ↘	↘ / ↘	↘ /
	10-15:hot	↘ / ↘	↘ / ↘	/
Sulfur Contents 96 → 22 ppm	11:cold	↘ / ↘	↘ / ↘	↘ / ↘
	10-15:hot	↘ / ↘	↘ / ↘	↘ / ↘
RVP 75 → 55KPa	11:cold	→ / ↘	→ / →	→ / →
	10-15:hot	→ / →	→ / →	→ / →
Benzene Contents 3.2 → 0.8 vol..%	11:cold	→ / →	→ / →	→ / →
	10-15:hot	→ / →	→ / →	→ / →

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Conclusion

- **Sulfur**
- **Influence is bigger for Lean burn and Direct Injection engine than conventional engine.**
- **For the cold mode(11mode) sulfur influences the catalyst light off.**

2) Proto-type vehicle show very low emission but ratio of influence is similar with the current vehicles.

Conclusion 2

3) Unregulated Emissions

Most of the emissions decrease with the reduction of THC. Measures to reduce THC is effective for the unregulated emissions.

4) Most of the data is consistent to the other auto/oil program even with the newest technologies such as lean burn, direct injection and NOx storage catalyst.

Future (STEP II Program)

Data of the Step1 is provided for the air quality calculation.

Sulfur level is very important for the lean burn engine which supposed to be the technology to cut CO2 emission.

For the next step, both CO2 and Emission consideration is necessary.

Decide the sulfur level for the future

Future (STEP II Program)

1. **Advanced technologies such as Direct injection engine aim to cut half of the current regulation emission vehicles are provided for the step II test.**

- **Tests are focused on sulfur influence with the mileage accumulation test.**

Fin