ETHANOL AND BIO-FUELS

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Aftertreatment Perspective

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Who are we

- ECMA are a non-profit Association, representing thirteen manufacturers of exhaust aftertreatment for mobile & stationary sources. We are comitted to collaboratively lead India towards Cleaner Air.

- We work with the Industry, Government Regulators, Oil Companies and the Public at large, to be a credible source of knowledge on emission control and we strive to increase awareness in emissions management by providing relevant technical solutions for this.

- We achieve this through assimilation of technologies, providing and disseminating knowledge enabling emission control. We hold Seminars and Conferences, pertaining to reducing pollution from automotive and powertrain exhaust sources

India ethanol economy – News soundbites

20 per cent ethanol-blending with petrol by 2023-24: Piyush Goyal

16 Jul, 2021, 07.21 PM IST

"By 2023-24, India is going to be 20 per cent blending ethanol in our petrol products. Our ultimate target is to also have vehicles which can take up to 100 per cent ethanol," he said at CII's Aatmanirbhar Bharat Conference and Exhibition-Self Reliance in RE (renewable energy) Manufacturing.

India's $7 billion bet to turn a fifth of its gasoline green

11 Jun, 2021, 04.16 PM IST

About 10 billion liters of ethanol will be required each year to meet the 20% ethanol-blended fuel standard by 2025, India's Oil Secretary Tarun Kapoor said in an interview with Bloomberg Television on Friday.

India to allow ethanol-based 'flex engines' in vehicles, launch scheme in 3 months: Nitin Gadkari

28 Jun, 2021, 04.35 PM IST

A switch to locally-produced ethanol will be helpful for a country like India which relies majorly on crude oil imports for powering the transport sector, he said, adding that it will also be less polluting and cost-saving.

India achieved 5.09% ethanol blending from December 1 to June 22: ISMA

29 Jun, 2020, 04.27 PM IST

The industry body informed that B-heavy molasses and sugarcane juice have been diverted away from sugar, to manufacture and supply 58 crore litres of ethanol to OMCs from in current year upto June 22.

India brings forward target of 20% ethanol-blending in petrol to 2025

05 Jun, 2021, 04.24 PM IST

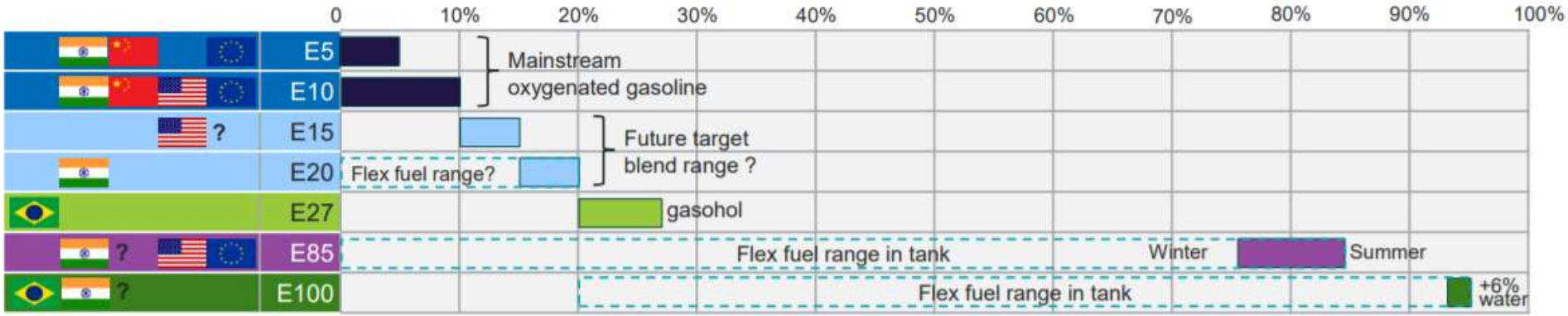
The government last year, had set a target for blending 10 percent ethanol in petrol by 2022, and 20 per cent by 2030. Currently, about 8.5 per cent ethanol is mixed with petrol as against 1-1.5 per cent in 2014.

Not 100% ethanol, blended fuel makes more sense: Narendra Taneja

12 Mar, 2021, 04.45 PM IST

If we start consuming ethanol for everything, we will end up becoming import dependent for ethanol also, says the energy expert.

Ethanol fuel blends – Market application



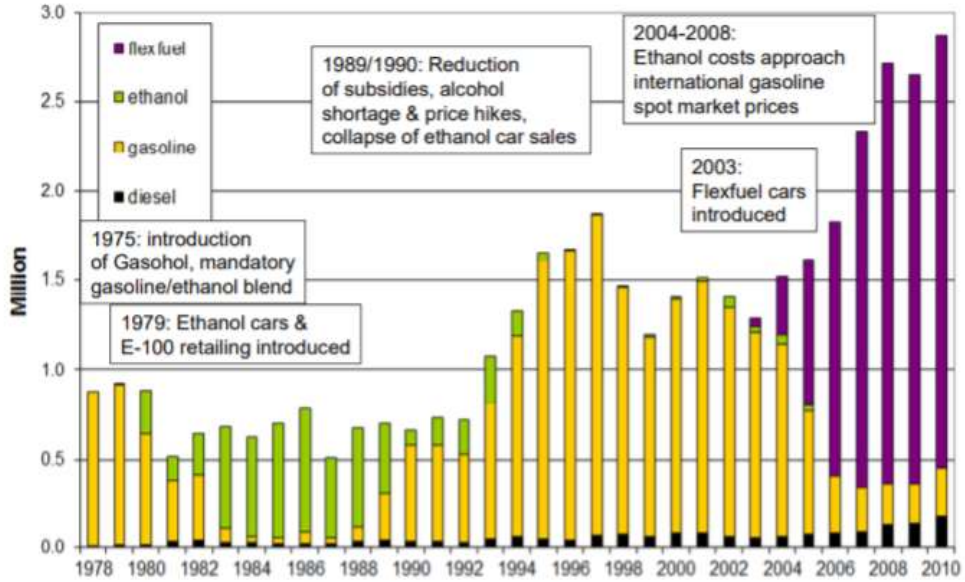
- Ethanol from bio sources is blended into fossil gasoline for a variety of reasons
  - Energy security via a substitution of imported crude oil with bio ethanol from home grown renewable ethanol crops
  - CO_2 benefits via carbon reduction
  - Air quality emissions benefits via HC ratio (de-carbonisation) and OC ratio (oxygenation)
- Almost all gasoline worldwide is blended with ethanol (oxygenated gasoline) with E5 to E10 being the most common blend rate range
- Blending ethanol into gasoline fundamentally affects the fuel properties and requires changes to the base engine and the vehicles fuel and aftertreatment system as well as the control system and calibration
  - Due to these application impacts as well as for commercial and distribution reasons, ethanol blend rates are controlled nationally in narrow bands
- The Indian market is investigating a range of options for increasing ethanol blend rates which will impact fuel production, distribution and the engine and vehicle applications for compatibility reasons and require significant investment for successful introduction

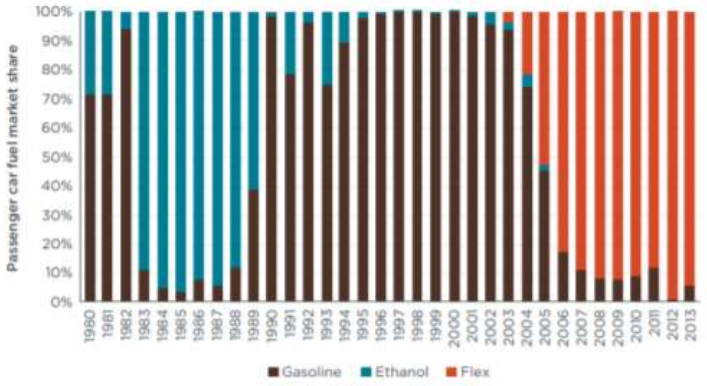
Vision – Indian Automobile Industry

Vehicle Category	2020 (BS-VI ↑)	2025	2030	2030 to 2047
2W	100% → E10	100% → E10 + M3 ↑ E20 fuel availability	100% → E20 + M3	Increase in CNG, HEV, BEV
3W (SI)	50% → CNG 50% → E5	100% → E10 + M3 75% → CNG	100% → E20+M3 100% → CNG	
3W (CI)	100% → B7			
4W (SI)	100% → E10	100% → E10 + M3 ↑ E20 fuel availability	100% → E20 + M3	
4W (CI)	100% → B7		↑ HEV ↑ BEV	
LCV	2% → CNG (cities) 98% →B7 (cities) 100% → B7 (rural)	5-10% → CNG 90-95% → B7	10% → CNG 90% → B7 ↑ED95, DME, HEV	
Buses	2% → CNG (cities) 98% → B7	5-10% → CNG 90-95% → B7	50% → CNG 50% → B7 + HEV (intercity) → DME, ED95	
M&HCV	100% → B7	5-7% → LNG or DME 93-95% → B7	10-15% → LNG or DME 85-90% → B7	

India's push for Flex Fuel Roll-out

Brazil- The Best Case Study For India for Flex Fuel roll out





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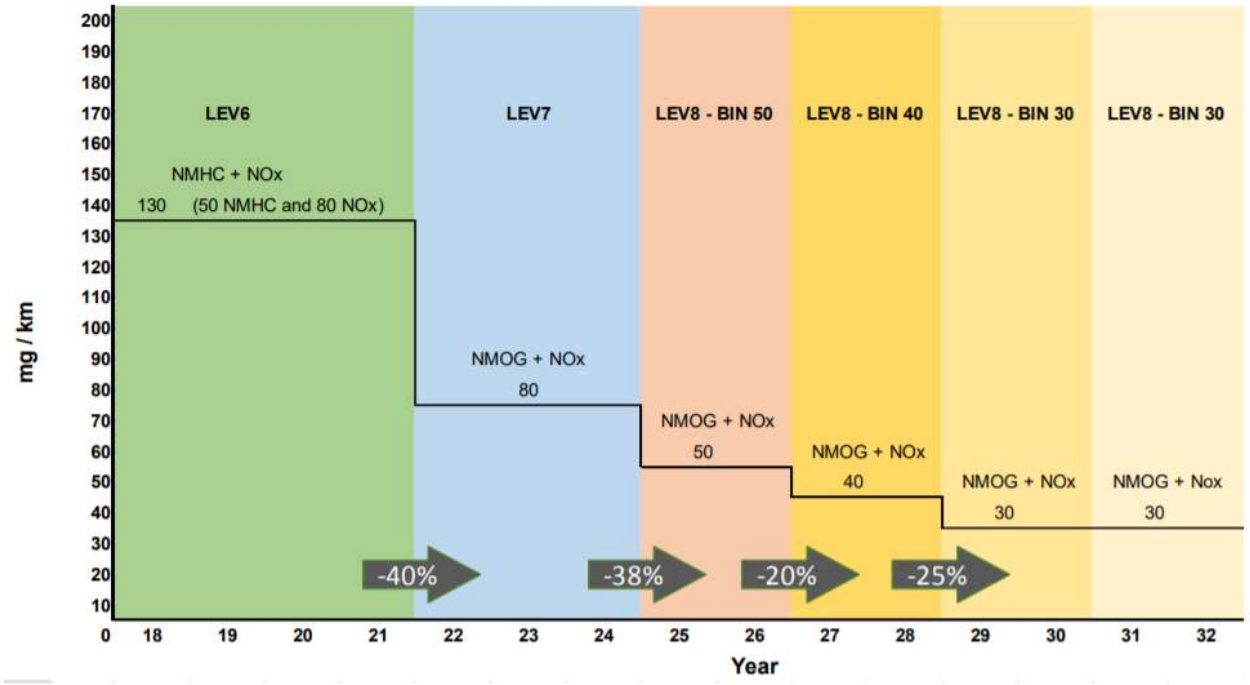
Emission Limits for Passenger Cars

Current and Future Emission Limits
Brazil– Gasoline Vehicles (E22/E100)



- Emission Cycle: FTP75
- Certification Fuels:
  - Gasoline E22,
  - Gasoline E61 (50/50): (E100+E22)/2
  - Ethanol E100

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Challenges of Ethanol

Flexfuel Challenges	E10	E20	E100	Impact on the Engine
RON, irregular combustion	Medium	Medium	High	In-cylinder pressure Thermal flux Compression ratio Spark plug thermal index TC matching Enrichment
Flame temperature	High	High	Low	Emissions Thermal flux Spark plug thermal index
Calorific value	High	High	Low	Vol. fuel consumption Injector / fuel pump layout Oil dilution
Vapour pressure	High	High	Low	Cold start
Composition	Blend	Blend	Single	Cold start Oil dilution / Lambda control Blowby Diagnosis
Latent heat of evaporation	Low	Low	High	Cold start Knocking / cooling
Oxidation	Low	Medium	High	Fuel system Spark plug

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Ethanol fuel blends – hardware impacts

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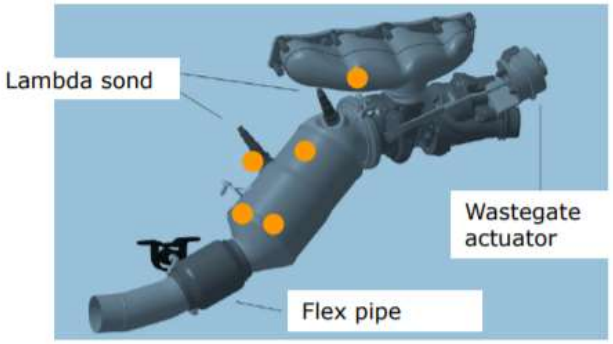
E100 Flex Fuel Application; Design and Mechanical Impact – Engine Periphery and Integration

Impact due to changed physical and chemical characteristics

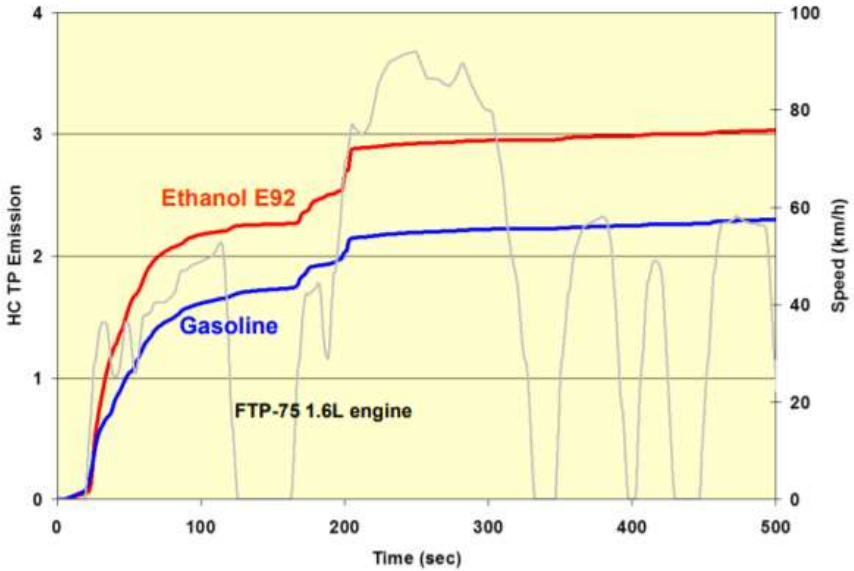


- Exhaust manifold (thermal and corrosion)
- Catalyst (aging thermal and chemical)
- Lambda sensor (thermal, chemical, physical-water shock)
- Gaskets (chemical)
- Oil quality sensor (change of electric conductivity)
- Tank, LP-System (chemical)
- Filter (chemical)
- Fuel pump (chemical, fuel flow increase)

Ethanol Exhibits Different Combustion Characteristics Compared to Gasoline

	Gasoline*	Ethanol*
Stoichiometric Air Fuel Ratio	14.3	9.0
Octane Number	92	111
Heat of Combustion (MJ/kg)	42.4	26.8
Latent Heat of Evaporation (kJ/kg)	420	845

*Koichi Nakata, Shintaro Utumi, et al. SAE Technical Paper Series, 2006-01-3380



- Start-up enrichment required
- Lower exhaust gas temperature contributes to delayed light-off
- Ethanol Flex-Fuel causes higher cold-start hydrocarbon emissions

Emission System Configuration and Catalyst Development Challenges

- Challenges for PL7 and PL8:
  - Change from NMHC to NMOG
  - Emission reduction and combination of NMOG+NOx
  - Increased durability to 160.000 km for PL7/8
  - Unburned ethanol not deducted from NMOG
  - Tighter OBD requirements
- System definitions and countermeasures
  - Increase of catalyst volume
  - Change from CC-only catalyst to CC1 + CC2/UF system
  - Increase of PGM content
  - Calibration improvements

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Basics of Emission Tests

- Emission tests on heavy vehicles commenced with tests on engines with engine dynamometers. This was more practical because of the size of vehicles.

- The European tests for Heavy Duty are on engine dynamometers while in North America some tests are done on chassis dynameters (rollers). India follows the European norm.

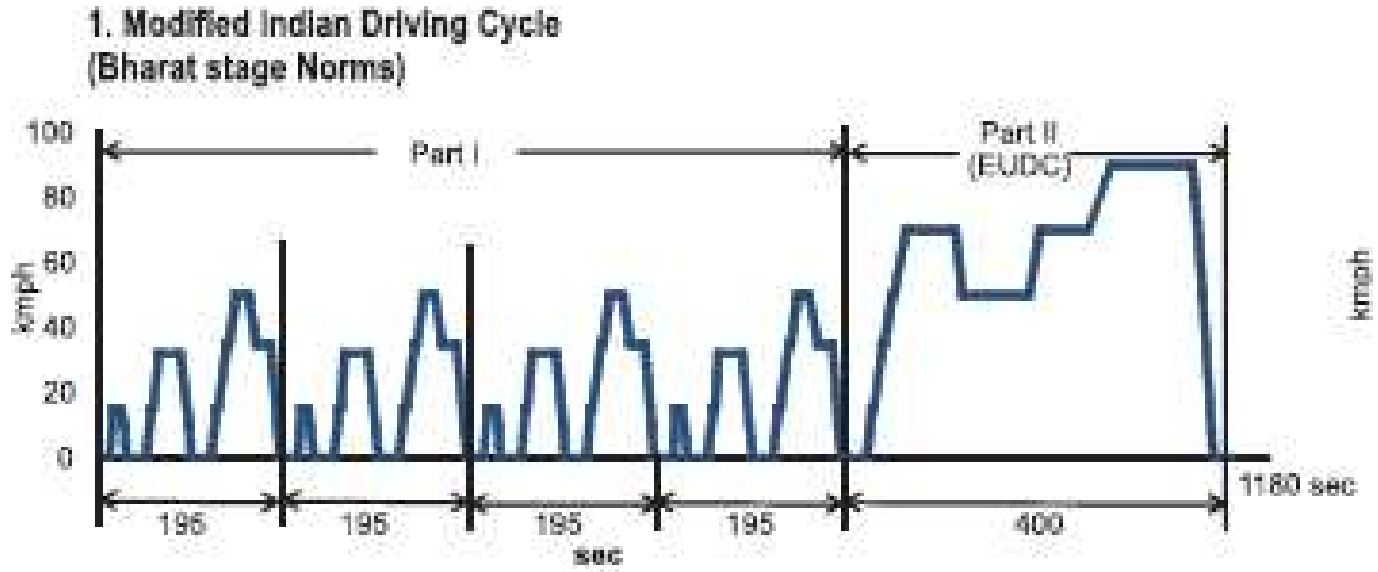
- Test results for pollutants are in gms/KW-hr for the test cycle on engine

- Vehicles are classified as ‘heavy’ according to certain criteria. Generally vehicles >3.5 ton GVW are tested for emissions using their engine.

Regulation Test Cycle for BS VI – Passenger Cars

Present Test Mode - MIDC with RDE

(Modified Indian Drive Cycle & Real Drive Emissions)

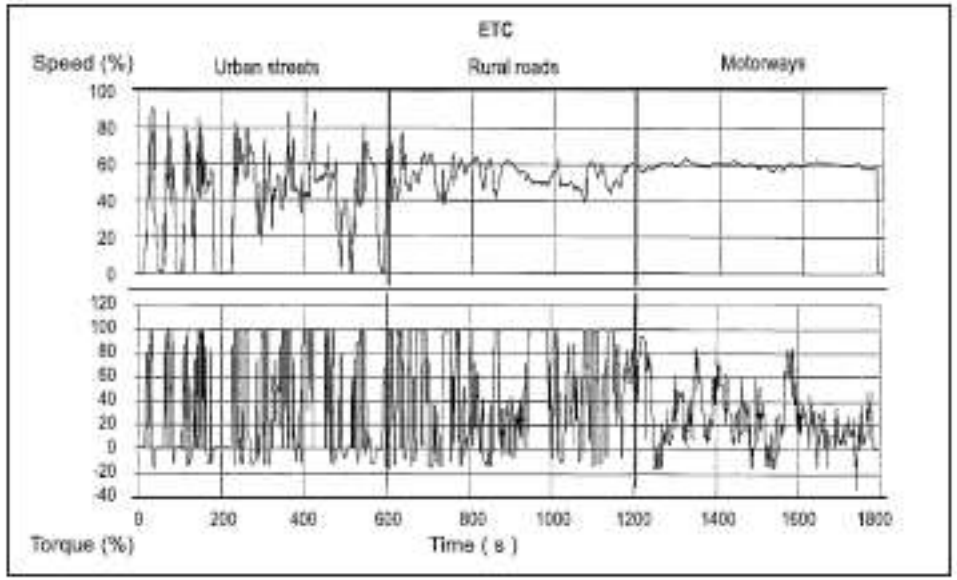


Total test time: 1180 sec
Total distance: 10.647 km
Max. speed: 90 km/h
Maximal Acceleration: 0.833 m/s2
Maximal Deceleration:1.389 m/s2

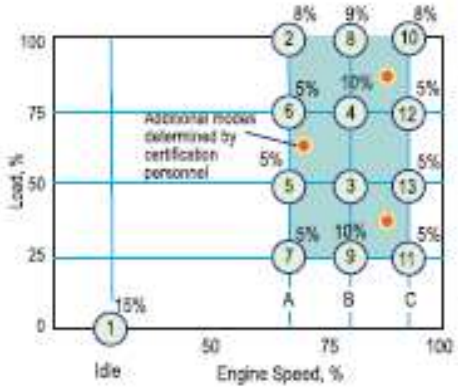
Emission Test Cycle – Heavy Duty GVW>3500Kgs.

Engine Transient Cycle (ETC) (BS - III & BS - IV)

ETC Dynamometer Schedule

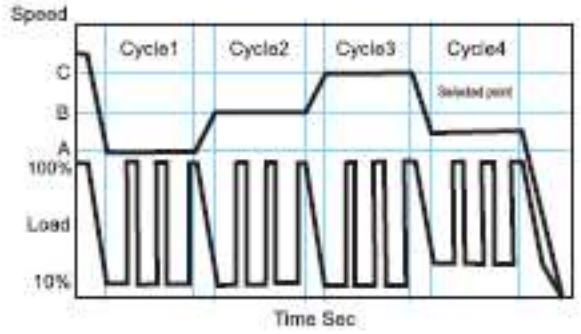


Engine Steady state cycle (ESC) (BSIII & BSIV)



Mode No.	Speed	Load %	Weight Factors
1	Low idle	0	15
2	A	100	8
3	B	50	10
4	B	75	10
5	A	50	5
6	A	75	5
7	A	25	5
8	B	100	9
9	B	25	10
10	C	100	8
11	C	25	5
12	C	75	5
13	C	50	5

ELR Test Sequence (BS - III & BS - IV)



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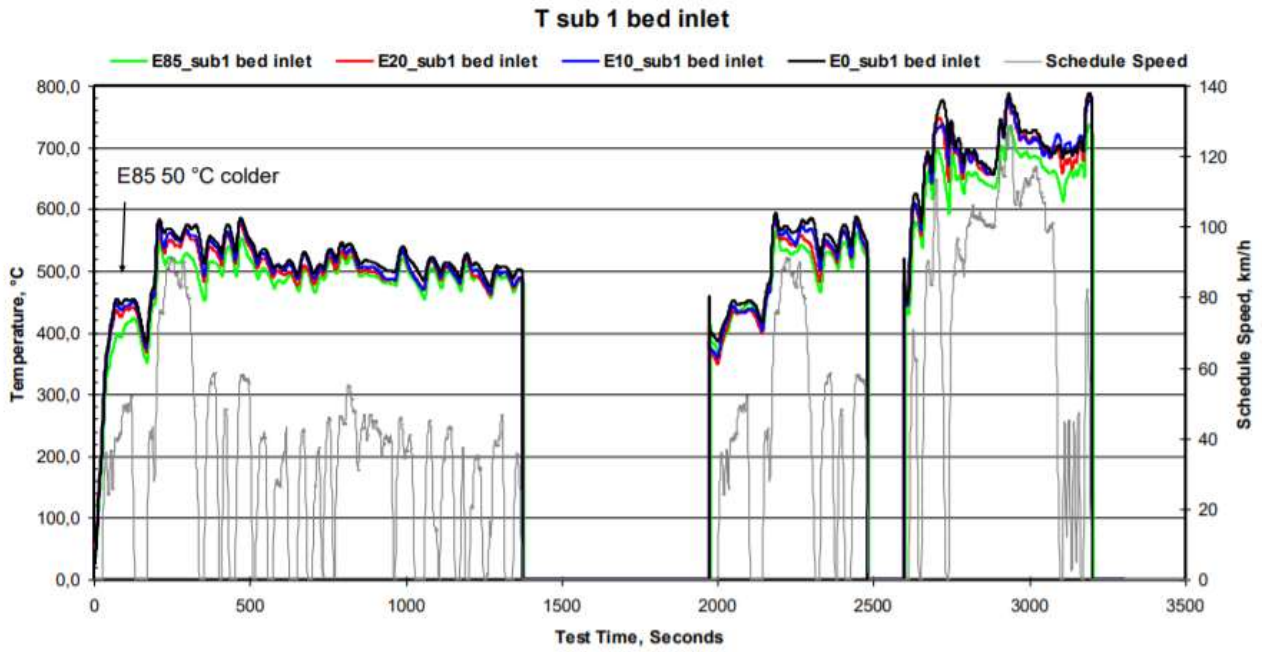
Real Driving Emissions (RDE)

Definition

RDE is a measurement method using portable emission measurement systems (PEMS) for emissions determination of vehicles under realistic conditions.

- Ordinary vehicles
- Public roads
- Operated at work-days
- Market fuels
- Data publicly available

Ethanol Effect on Temperature



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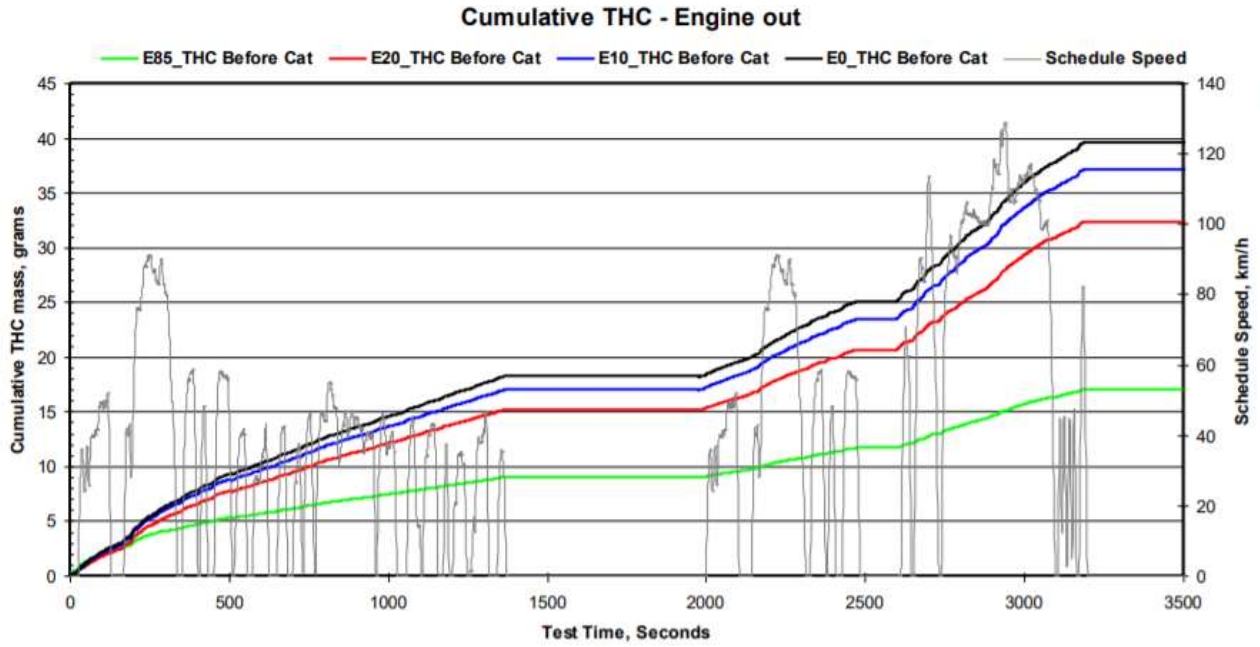
Effect Of Blending on THC



Engine-out hydrocarbons decrease proportionally t o the ethanol content.
THC E0 > THC E10 > THC E20 >> THC E85

With E85, the feed-gas THC are halved with respect to E0 (53% on FTP, 56% on US06 cycle)

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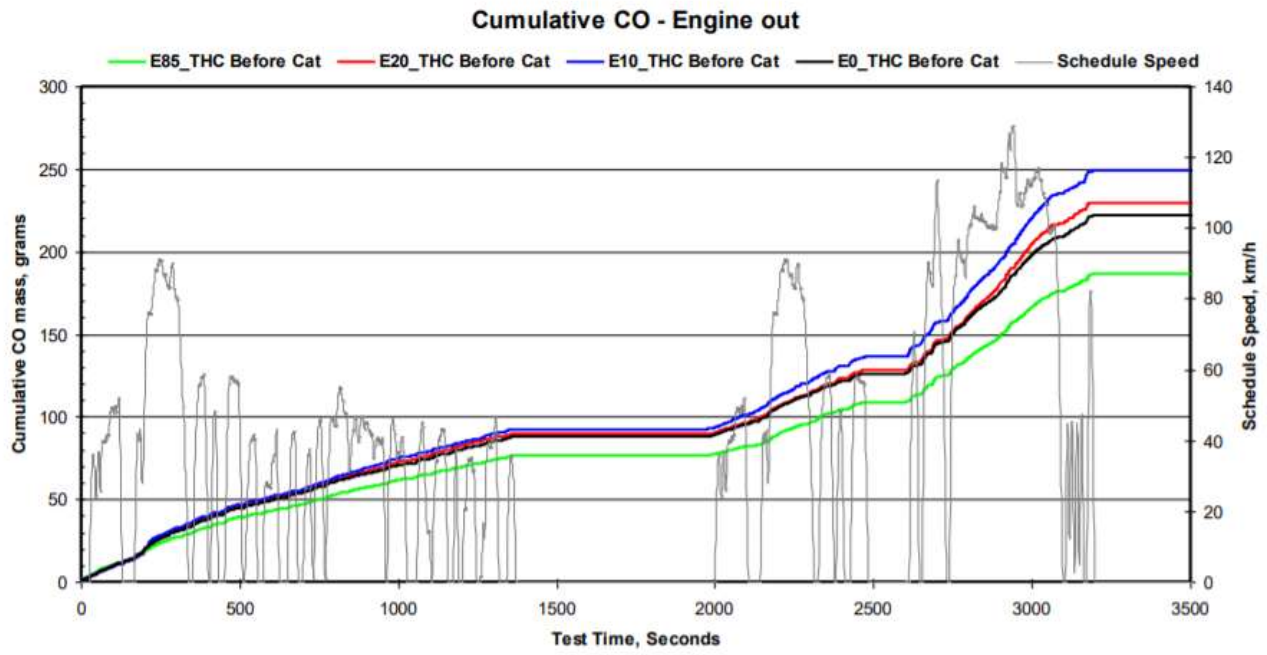
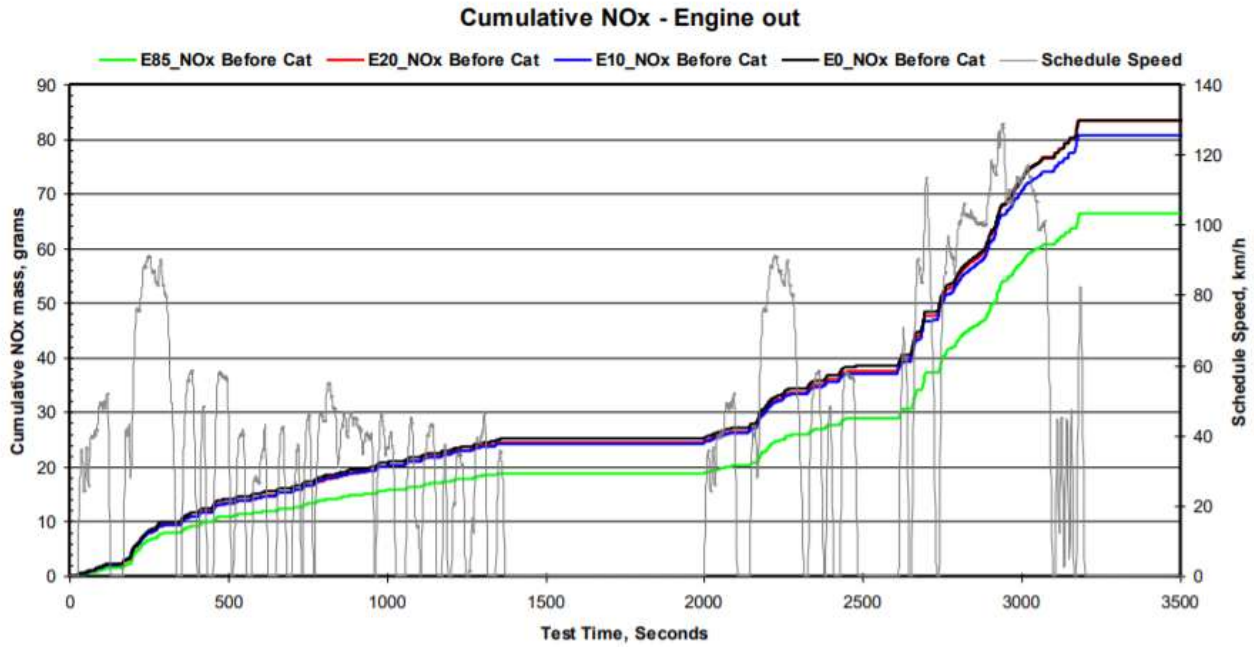
Effect Of Blending on CO



Effect Of Blending on NOx



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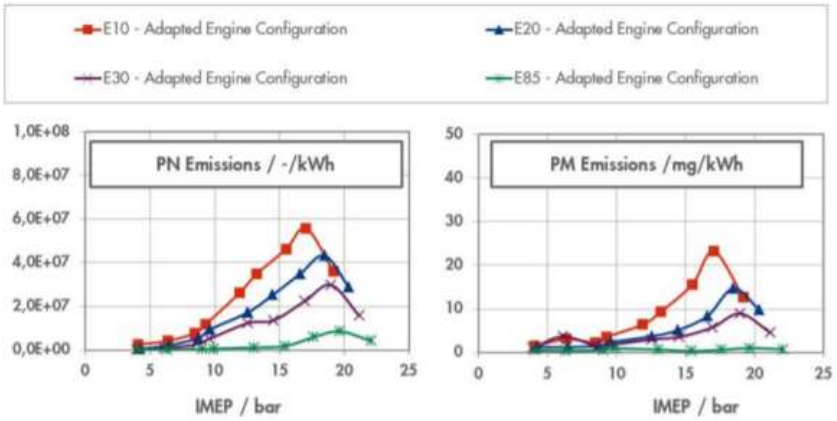
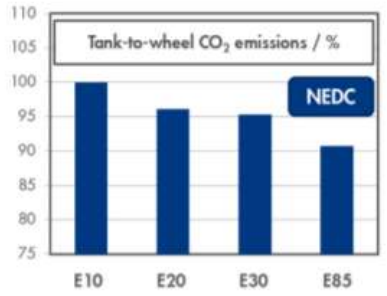
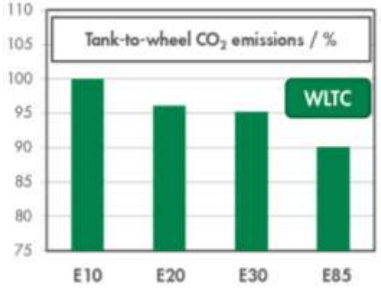
Effect Of Blending on PN/PM & CO2







Ref: 25th Aachen Colloquium Automobile and Engine Technology 2016

Emission Limits for Passenger Cars

Current and Future Emission Limits
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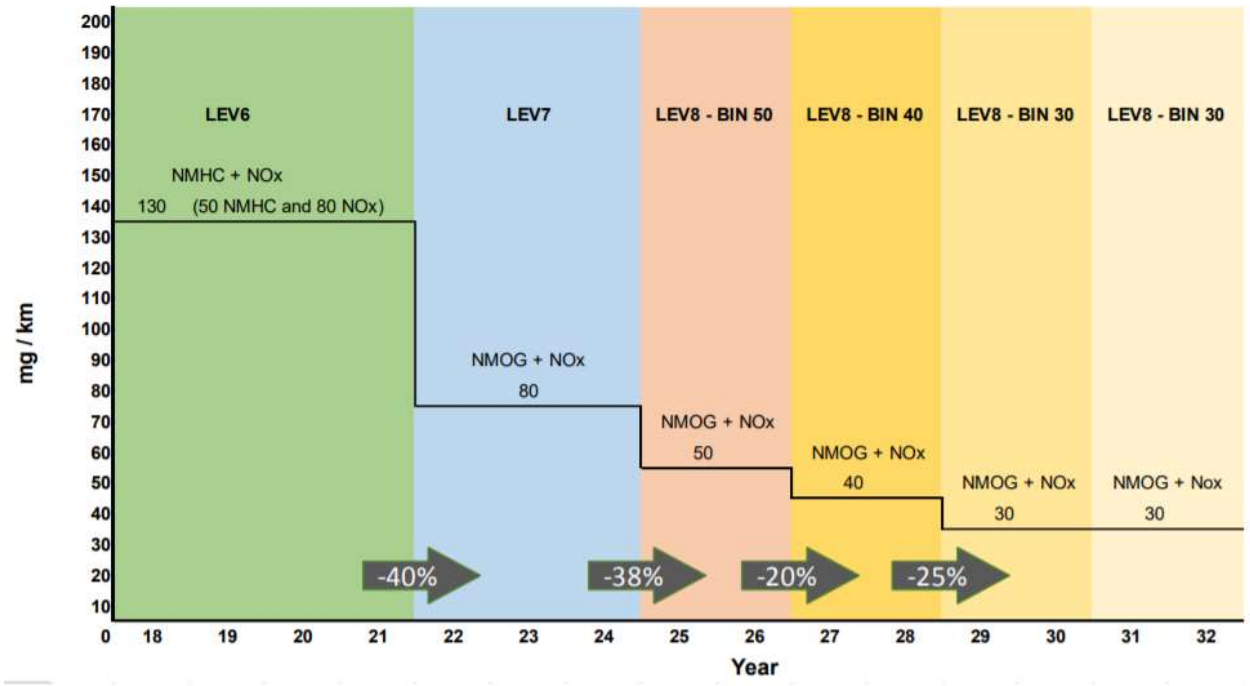

- Emission Cycle: FTP75
- Certification Fuels:
  - Gasoline E22,
  - Gasoline E61 (50/50): (E100+E22)/2
  - Ethanol E100

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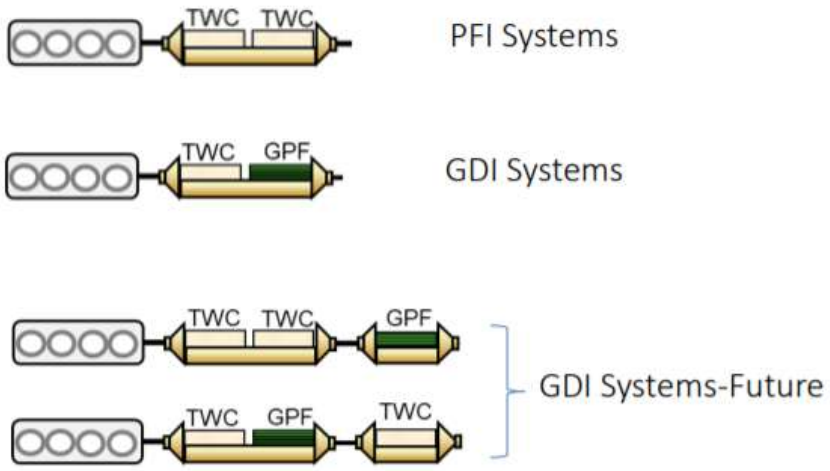
Flex Fuel ATS Layout

After-Treatment Preparedness For Ethanol Flex Fuel- Layout

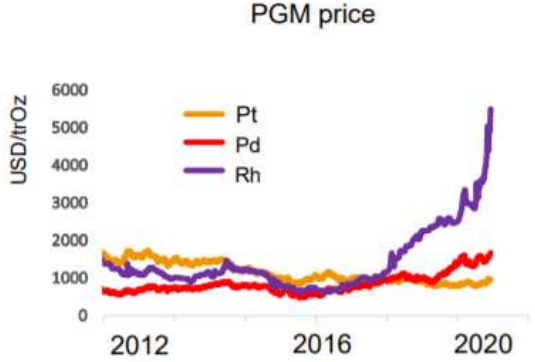


BASF Workstreams for Cost Effective Emission Reduction Systems

Technology Improvement

- Continuous TWC and FWC performance improvement programs including advancement of support material

Substitution of Pd with Pd and Reduction of Rh



- Set-up of global trimetal team for performance improvement

Global Footprint

- Leverage BASF global expertise to provide market specific catalyst solutions

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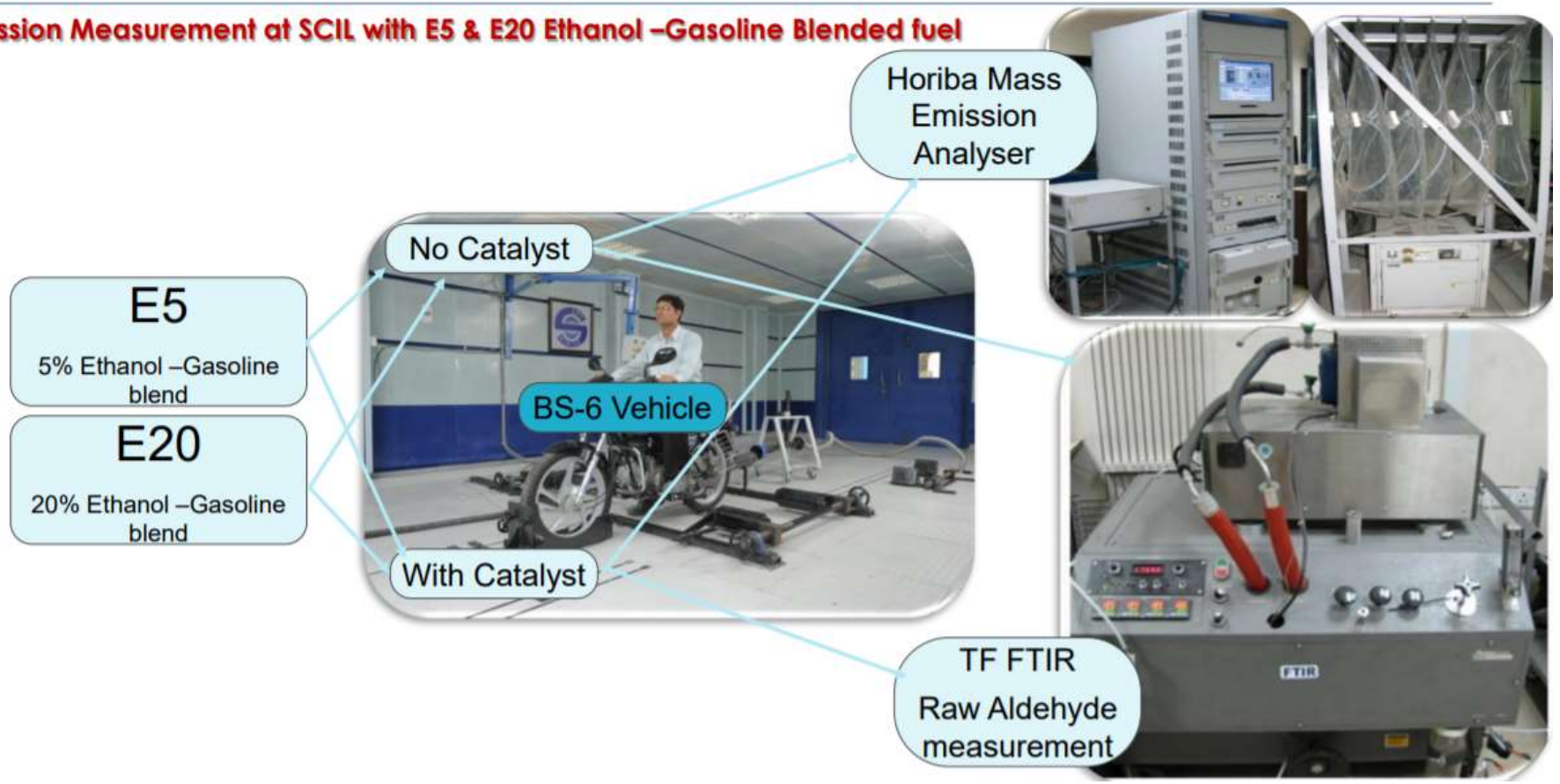
CREATING PERFORMANCE TECHNOLOGY

Emission Measurement at SCIL with E5 & E20 Ethanol –Gasoline Blended fuel



Conclusion:

- *After-Treatment solutions for Ethanol(E20) and Flex fuel are available readily based on the Brazil experience*
- ***Hydrocarbons***

With increasing ethanol content, CH_4 emissions increase due to cracking of ethanol, NMHC stays almost the same

*→ 2 critical points for **E85***

light off: ethanol emissions

warmed-up: CH_4

- ***NOx and CO***

Are extremely depending on air to fuel ratio = calibration.

Hence OEMs need to focus more on calibration robustness

- ***Our After- Treatment Systems Ready for future L-8 emission kind***

Vehicle category	NMOG + NO_x mg/km	PM[a] mg/km	CO mg/km	Aldehydes[c] mg/km	NH_3[b] ppm	Evaporative[c] g/test	Refueling[e] mg/L supplied
Passenger vehicles	80	6	1,000	15	Declare	0.5	50
Light commercial vehicles	140[d]	6[c]					
	320[d]	20[d]					

(a) Applicable to vehicles equipped with diesel engines or direct injection SI engines
(b) Applicable to vehicles equipped with diesel engines with aftertreatment systems using a liquid reducing agent
(c) Applicable to vehicles equipped with SI engines
(d) Applicable to vehicles equipped with diesel engines
(e) Not applicable to vehicles fueled by diesel or compressed natural gas

L7

L8

			Level	NMOG+NO_x mg/km	PM[a] mg/km	CO mg/km	Aldehydes[c] mg/km	NH_3[b] ppm	Evaporative[c] g/test	Refueling mg/L fuel supplied
Diesel LCVs	Spark-ignition LCVs (test mass > 1700 kg)	PVs and LCVs (test mass ≤ 1700 kg)	320	320	20	1000	–			
			280	280	20	1000	–			
			250	250	20	1000	–			
			220	220	10	1000	–			
			200	200	10	1000	–			
			170	170	9	1000	–			
			140	140	6	1000	15			
			110	110	6	1000	15	10	0.5	50
			80	80	6	1000	15			
			70	70	4	600	10			
			60	60	4	600	10			
			50	50	4	600	10			
			40	40	4	500	10			
			30	30	3	500	8			
			20	20	2	400	8			
			0	null	null	null	null	null	null	null

(a) Applicable to vehicles equipped with diesel engines or direct injection SI engines
(b) Applicable to vehicles equipped with diesel engines with aftertreatment systems using a liquid reducing agent
(c) Applicable to vehicles equipped with Otto cycle engines

Corporate average emission limits for the L-8 standards are shown in Table 4. The limits correspond to emission levels included in Table 3, which define corporate average emission limits for each regulated pollutant. For example, in 2025, the corporate average emission level for passenger vehicles is set at 50, which corresponds to fleet-average emission limits of 50 mg/km for NMOG+NO_x, 4 mg/km for PM, 600 mg/km for CO, and 10 mg/km for aldehydes.

Corporate average emission levels for PROCONVE L-8 standards

Implementation date	PV corporate average emission level	LCV corporate average emission level
January 1, 2025	50	140
January 1, 2027	40	110
January 1, 2029	30	90
January 1, 2031	30	30

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- Substrate manufacturers are :

CORNING, NGK TECHNOLOGIES INDIA, vitesco TECHNOLOGIES, IBIDEN, NSMAT

- Coaters are:

Johnson Matthey Inspiring science, enhancing life, BASF We create chemistry, umicore, SÜD-CHEMIE CREATING PERFORMANCE TECHNOLOGY

- System Integrators are:

TENNECO, Albonair, Cummins Emission Solutions, UNIFRAX

THANK YOU

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