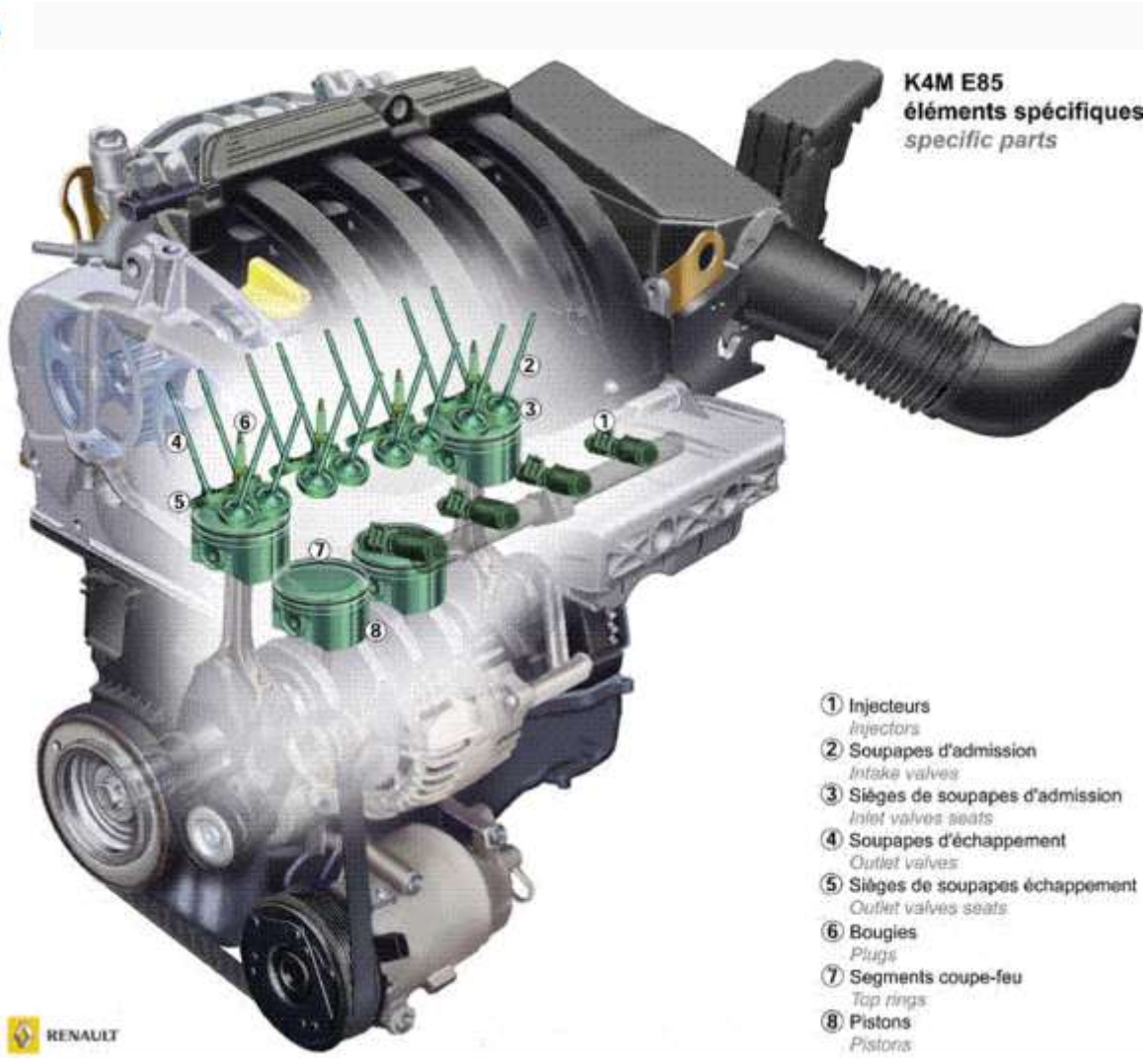
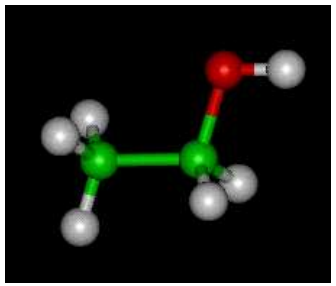
ECMA
Clean Air Today, Cleaner Air Tomorrow



umicore
materials for a better life



C_2H_5OH

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Ethanol Blending- EXX

Date : 22.10.24

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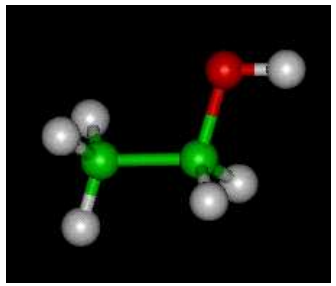
WHAT IS ETHANOL- STRUCTURE-PROPERTIES



The chemical compound **ethanol**, also known as **ethyl alcohol** or **grain alcohol**, is the bio-alcohol found in alcoholic beverages.
When non-chemists refer to "**alcohol**", they almost always mean ethanol.
It is also increasingly being used as a fuel (usually replacing or complementing gasoline).
Ethanol's chemical formula is C_2H_5OH.

Chemical and Physical Properties of the Ethanol Molecule

Properties

Pure ethanol is a flammable, colorless liquid with a boiling point of 78.5° C.
Its low melting point of -114.5° C allows it to be used in antifreeze products. It has a pleasant odor reminiscent of whiskey.
Its density is **789 g/l** about 20% less than that of water. It is easily soluble in water and is itself a good solvent, used in perfumes, paints and tinctures. Alcoholic drinks have a large variety of tastes,

Ethanol as fuel

Ethanol is flammable and burns more cleanly than many other fuels.
When fully combusted its combustion products are only carbon dioxide and water. For this reason, it is favoured for environmentally conscious transport schemes and has been used to fuel public buses.
However, pure ethanol attacks certain rubber and plastic materials and cannot be used in unmodified car engines.
Additionally, ethanol has a much **higher octane** rating than ordinary gasoline, requiring changes to the **spark timing in engines**.
A mixture containing gasoline with at least 10% ethanol is known as gasohol. One common gasohol variant is "E15", containing 15% ethanol and 85% gasoline. These concentrations are generally safe for regular automobile engines, and some regions and municipalities mandate that the locally-sold fuels contain limited amounts of ethanol.
The term "E85 ethanol" is used for a mixture of 15% gasoline and 85% ethanol. Beginning with the model year 1999, a number of vehicles in the U.S. were manufactured so as to be able to run on E85 fuel without modification.

WHAT IS ETHANOL- FOSSILE PROPERTIES

Fuel	Gasoline	Ethanol	n-Butanol	2,5-Dimethylfuran
Molecular formula	C_2–C_{14}	C_2H_5OH	C_4H_9OH	C_6H_8O
Molecular weight (g/mol)	110.8	46.07	74.12	96.1
Research octane number	93.1	107	96	119
Density at 20 °C (g/mL)	0.745	0.789	0.81	0.89
Lower heating value (MJ/L)	32.9	21.3	26.9	29.3
Laminar flame burning speed at 1 bar, 390K (cm/s)	52	63	57	50
Viscosity at 20 °C (cSt)	0.4–0.8	1.52	3.35	0.57
Surface Tension at 20 °C (mN/m)	20–25	22.39	24. 6	25.9
Vapor Pressure (kPa)	55–103	18	4.08	1.253
Boiling point (°C)	35–210	78	117	92
Latent heat of vaporization (kJ/kg)	180–373	840	546	332
H/C ratio	1.8	3	2.5	1.3
O/C ratio	0	0.5	0.25	0.167
Stoichiometric A/F ratio	14.56	8.95	11.13	10.72
Stoichiometric CO_2 (kg/L, fuel)	2.38	1.51	1.93	2.45

Fuel	Density at 20 °C (g/mL)	Lower Heating Value (MJ/L)	H/C Ratio	O/C Ratio	Stoichiometric A/F Ratio
E20	0.754	30.6	2.0	0.07	13.27

		Block I			
	Unit	Fuel A	Fuel B	Fuel C	Fuel D
Ethanol Content	% vol	10	20	30	85
RON		96.5	99	101	107
MON		85	87	88	89
Octane Sensitivity		11	12	13	18
Heat of Vaporisation	kJ/kg	428	490	551	864
Calorific Value	MJ/kg	41,6	40,1	38,4	29,6
	MJ/L	30,8	30,0	28,9	23,3
Density	kg/m3	742	747	753	786

Ref: energies-MDPI

Brazil Emissions-L8

			Level	NMOG+NO_x	PM[a]	CO	Aldehydes[c]	NH_3[b]	Evaporative[c]	Refueling
				mg/km	mg/km	mg/km	mg/km	ppm	g/test	mg/L fuel supplied
Diesel LCVs			320	320	20	1000	–			
			280	280	20	1000	–			
			250	250	20	1000	–			
			220	220	10	1000	–			
			200	200	10	1000	–			
			170	170	9	1000	–			
	Spark-ignition LCVs (test mass > 1700 kg)		140	140	6	1000	15			
			110	110	6	1000	15	10	0.5	50
		PVs and LCVs (test mass ≤ 1700 kg)	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	50
January 1, 2031	30	30

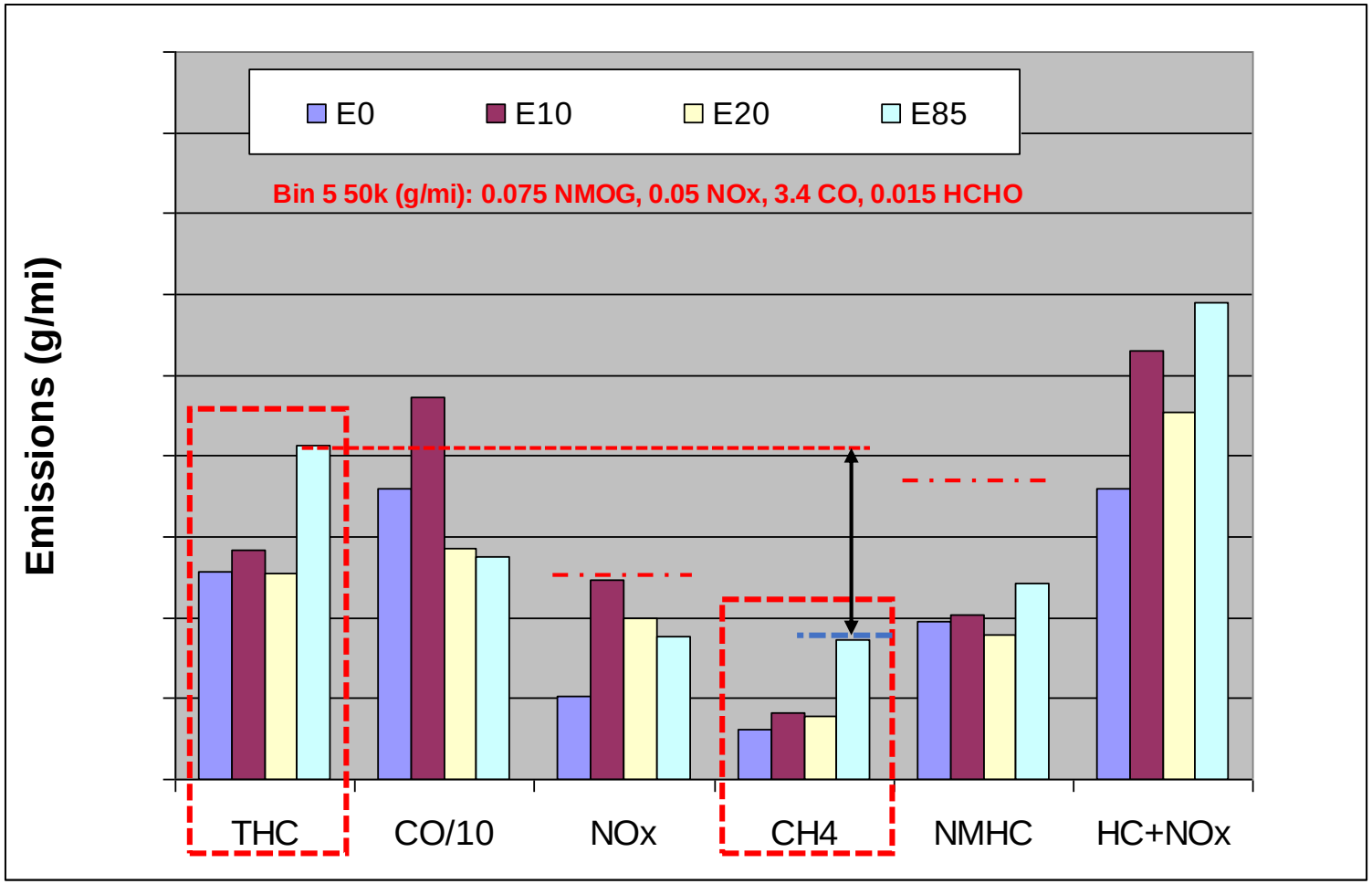
Umicore Ethanol Project

North America Project layout

- Vehicle: 3.5 V6 Flex Fuel Bin 5 (CC1 & CC2)
- Aging: four mode aging equivalent to 4k and 120k miles
- Fuels: E0, E10, E20, E85
- Test Cycle: FTP 75, US06
- CC1 82g/ft³on 400/4 (0.58L)
- CC2 25g/ft³on 400/4 (1.12L)

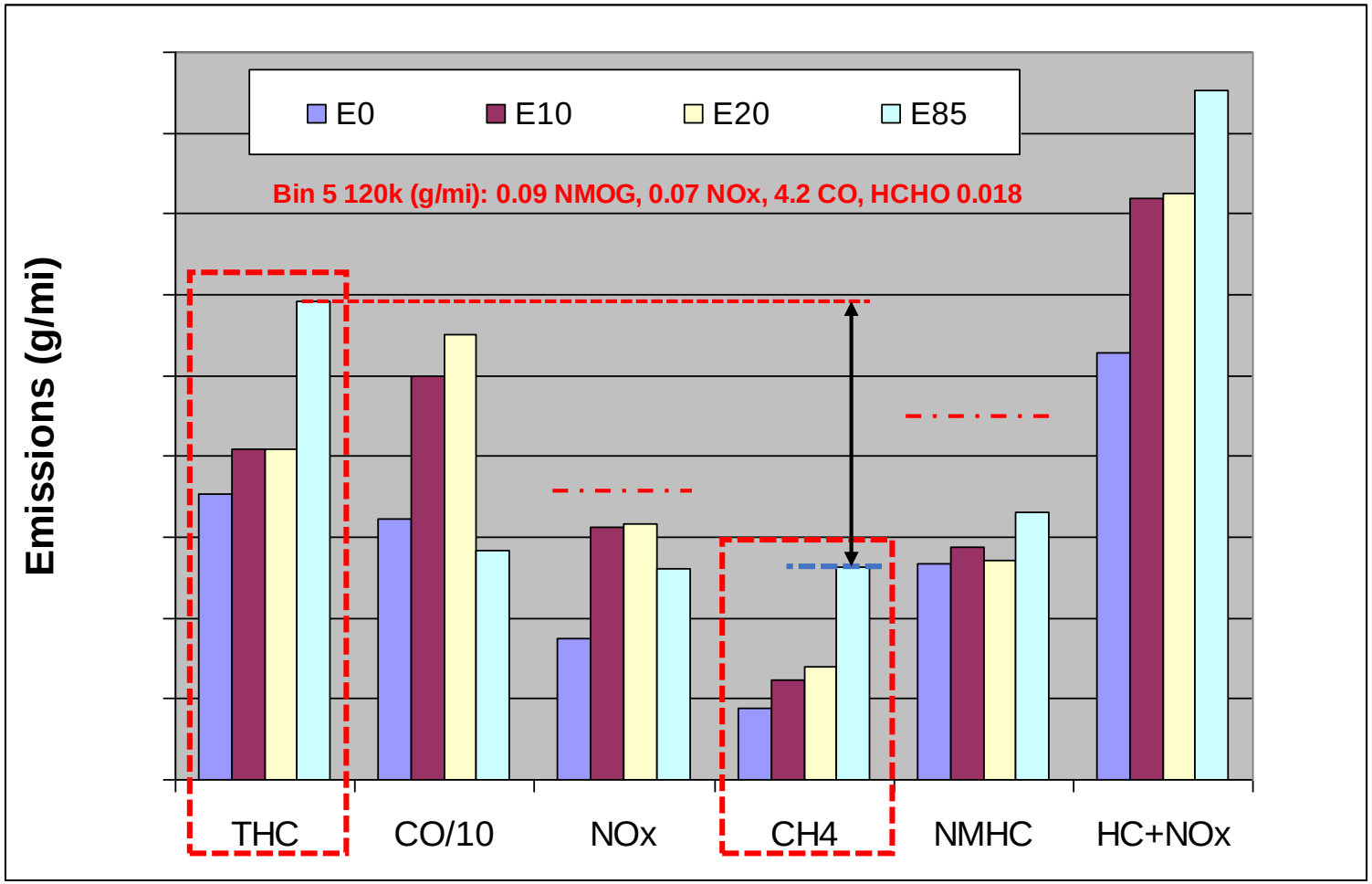
FTP Bag Results

4k FTP Bag Emissions



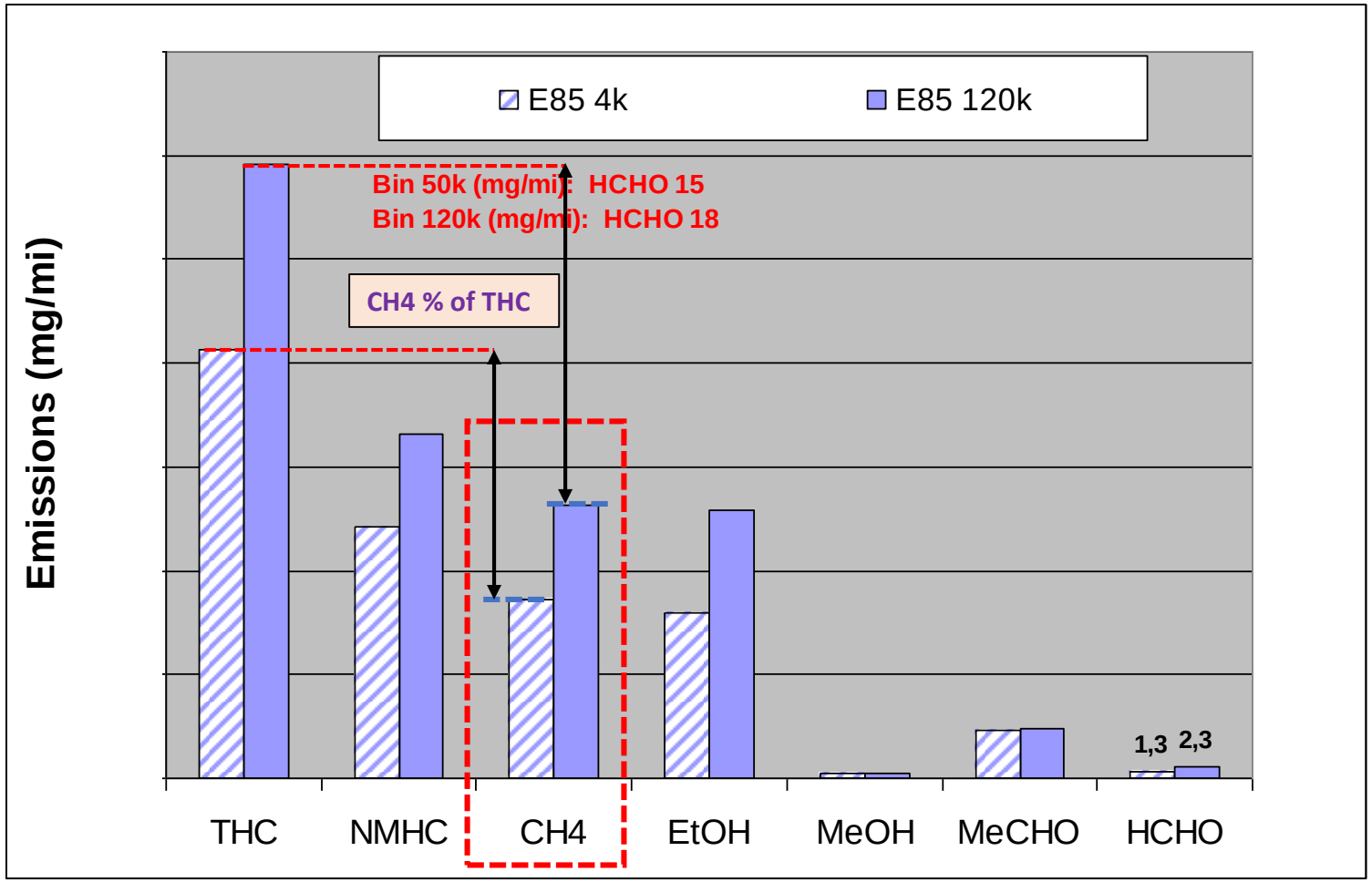
* average of 3 tests

120k FTP Bag Emissions



* average of 3 tests

E85 FTP HC Emissions by components



* average of 3 tests

Summary FTP Bag Emissions

- 4k
- THC: Higher CH_4 emissions due to cracking of Ethanol for E85, but E10 and E20 equal to E0, NMHC almost unchanged
- CO, NOx: Maximum for E10

120k

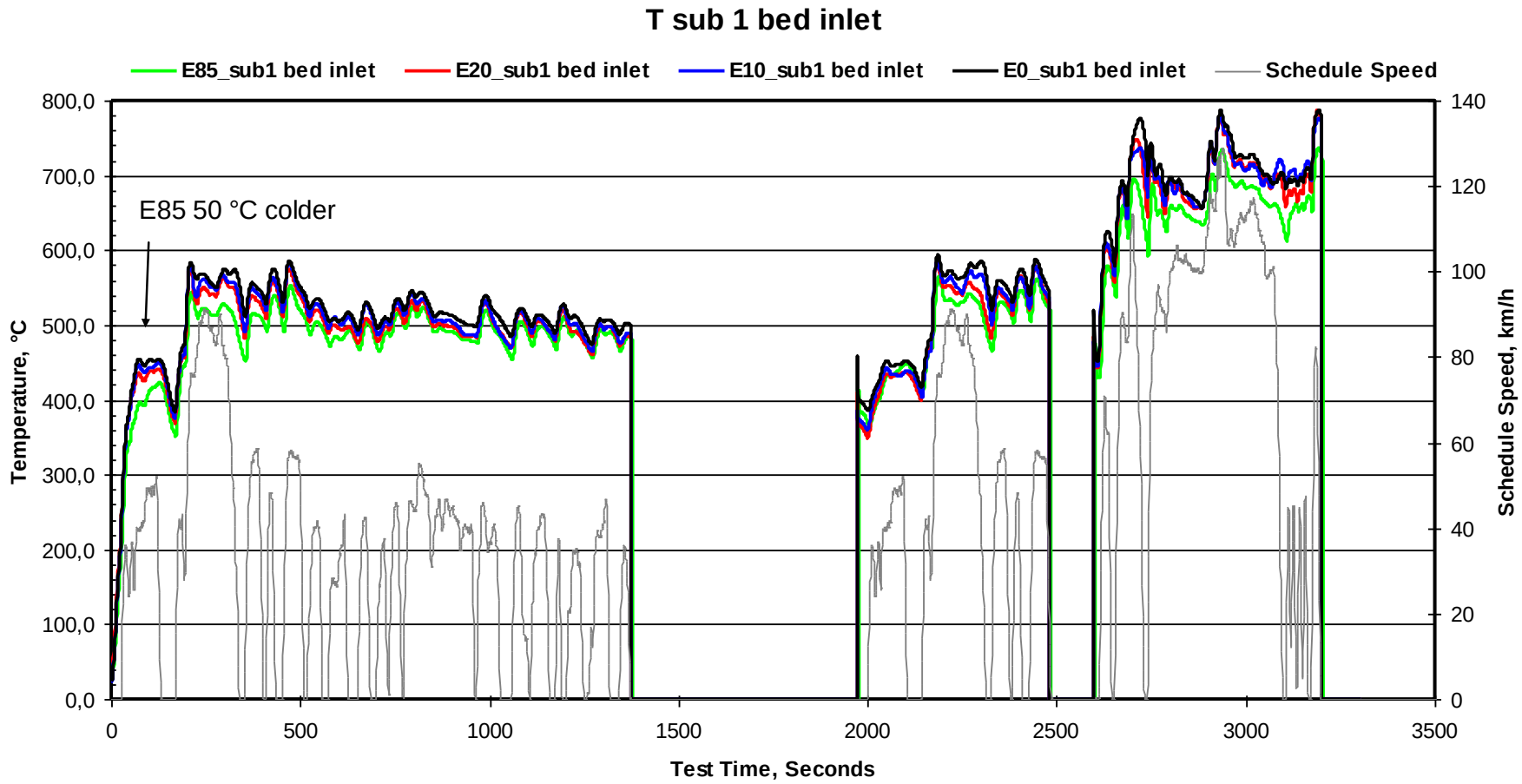
- THC: Higher CH_4 emissions for E10 and E20, **much higher for E85**, NMHC almost unchanged
- CO, NOx: Clearly increased for E10 and E20, but not for E85

Both agings some acetaldehyde, almost no formaldehyde

FTP+US06 Modal Data

120k

Ethanol Effect on Temperature



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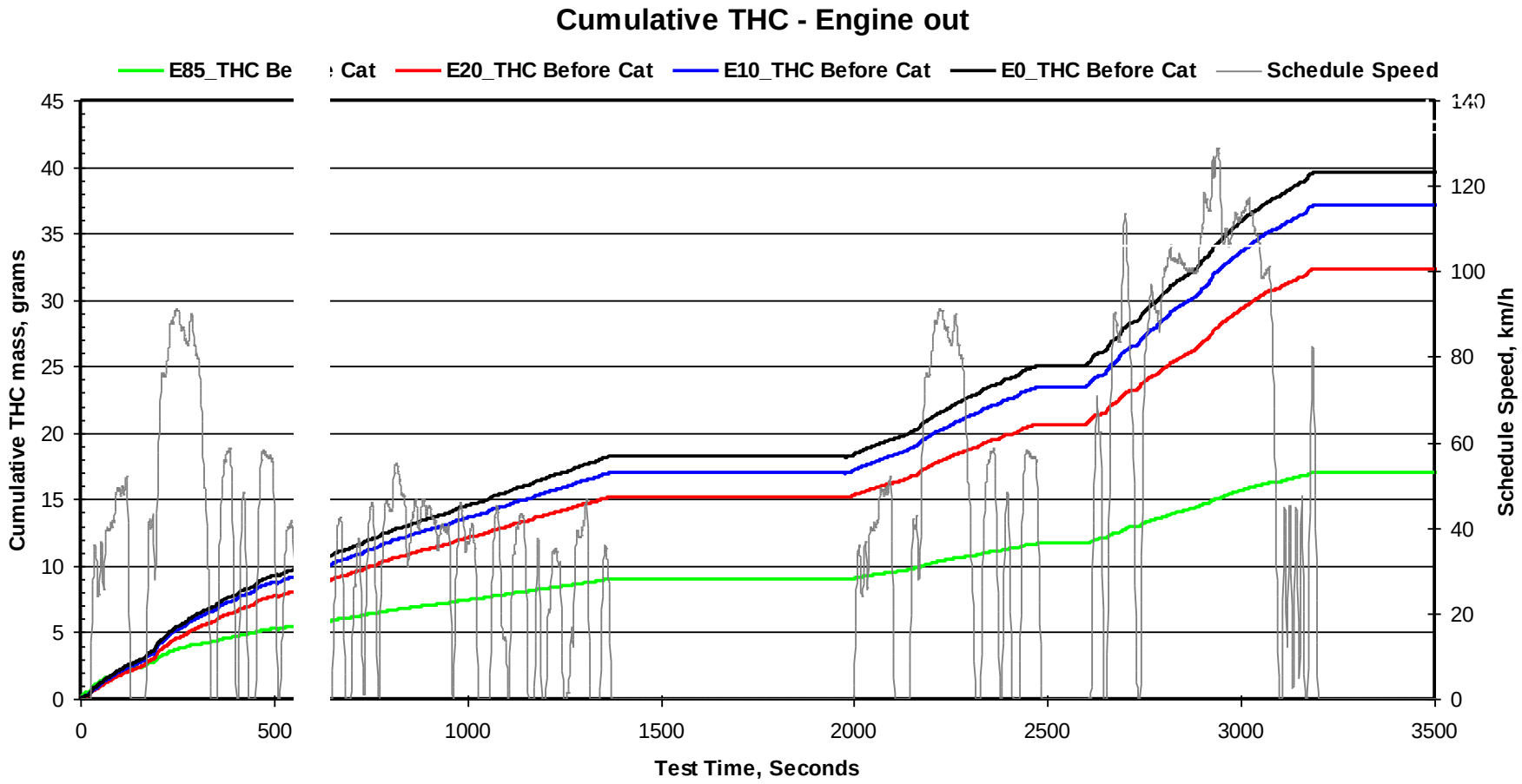
Effect Of Blending on THC

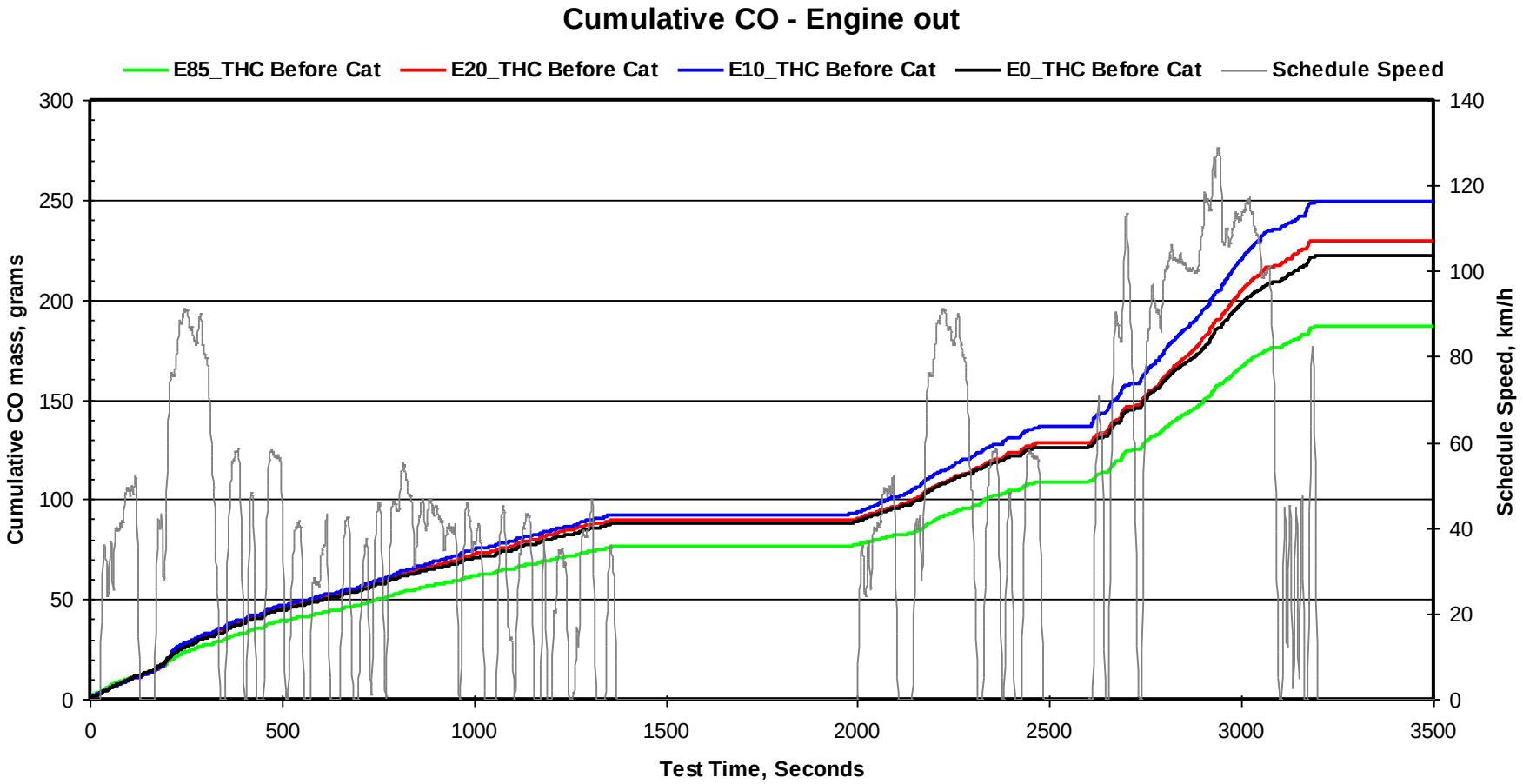


Engine-out hydrocarbons decrease proportionally t o the ethanol content.

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)

Effect Of Blending on CO



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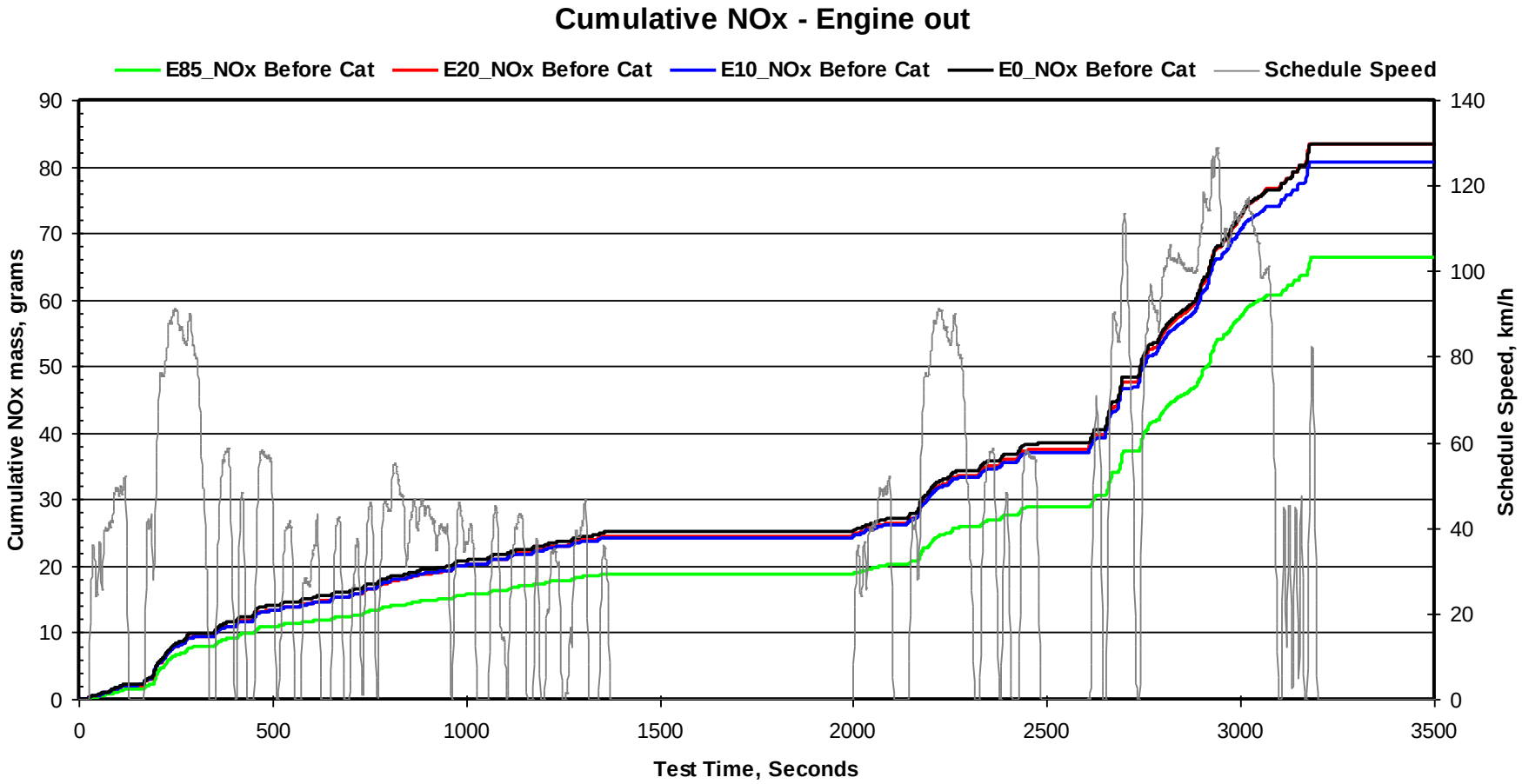
Effect Of Blending on NOx



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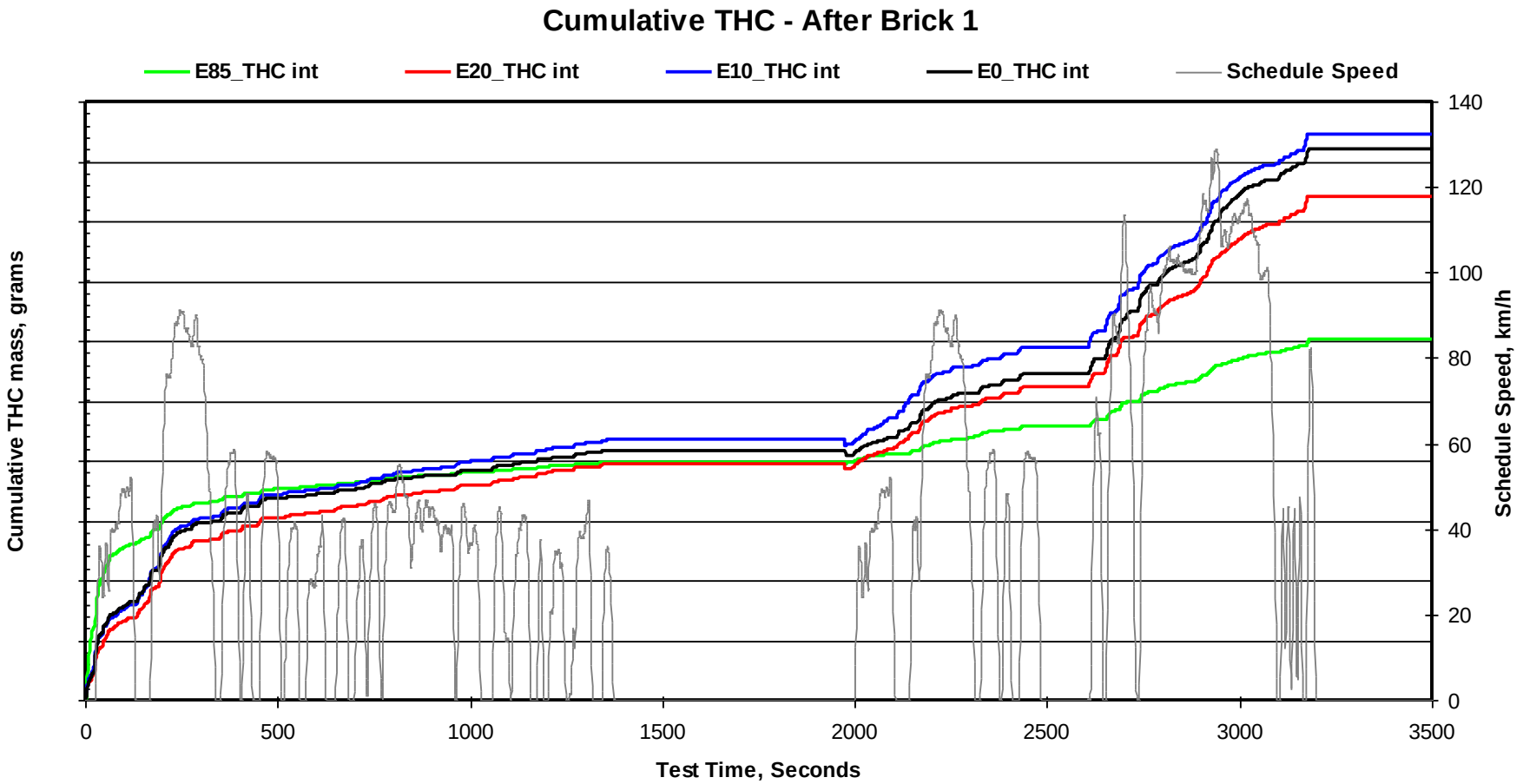
• THC after Brick 1-FTP+US06 Modal Data

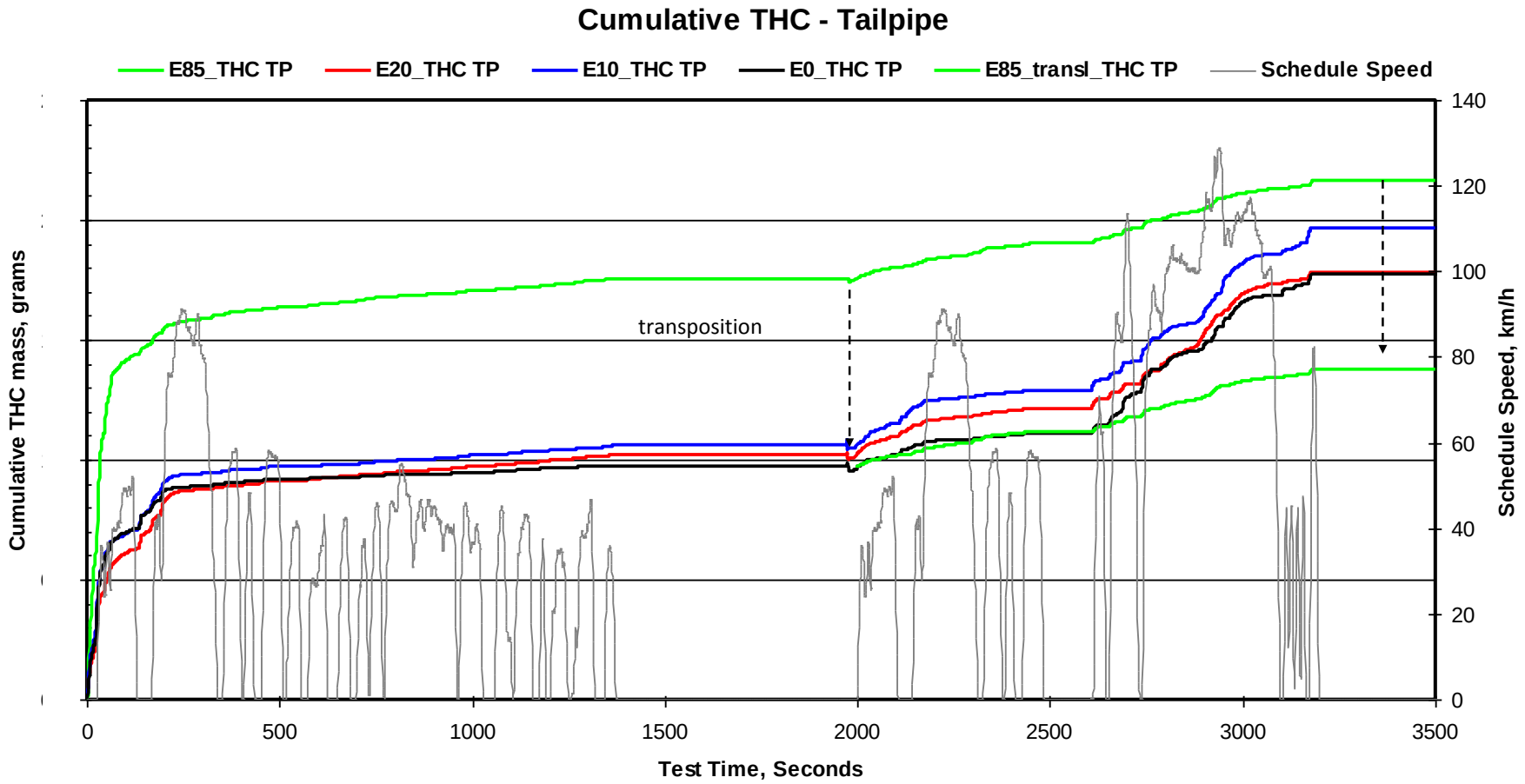


THC after CC1

- First 500s of the cycle: THCs significantly higher with E85 (cold start-problem), but in warmed-up phase lower than for all other fuels, especially for US06.
- E10 has the highest emissions, the difference comes mainly from restart and following acceleration

THC E10 > THC E0 > THC E20 >> THC E85

THC tailpipe-FTP+US06 Modal Data



THC after CC2

- Cold start problem for E85
- E10 has the highest emissions, the difference comes mainly from restart and following acceleration and US06

THC E85 > THC E10 > THC E0 = THC E20

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 emissions*