Selective ammonia slip catalyst enabling highly efficient NOx removal requirements of the future

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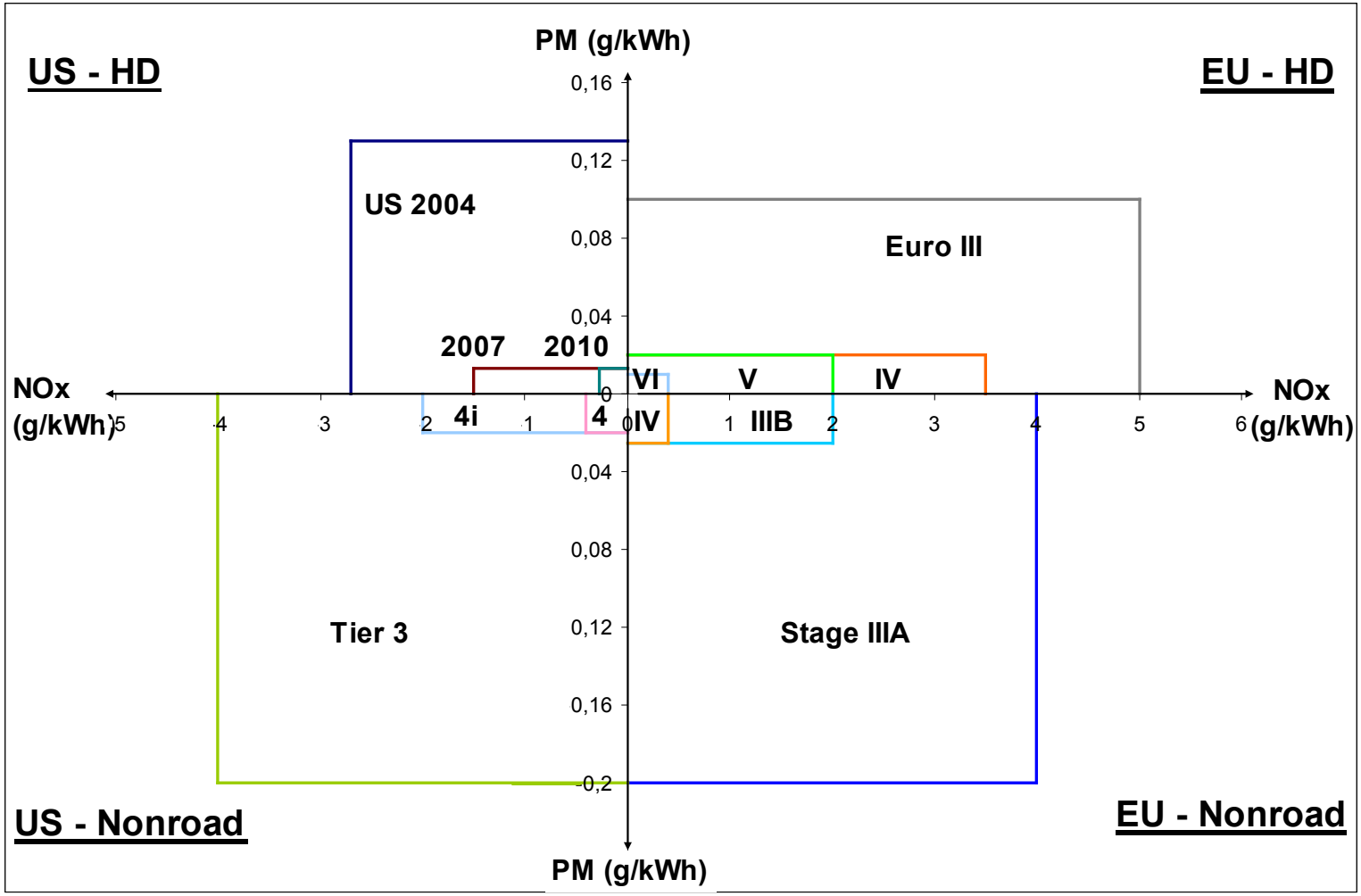
Outline

- Motivation
- Design goals
- Catalyst development
- Results of engine tests
  - 12L ASC
  - 3L ASC
- Concluding remarks

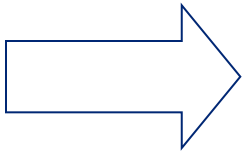
Motivation



- Ammonia slip also regulated
  - 10ppm (Euro VI), 25ppm (Stage IV)

Design goals

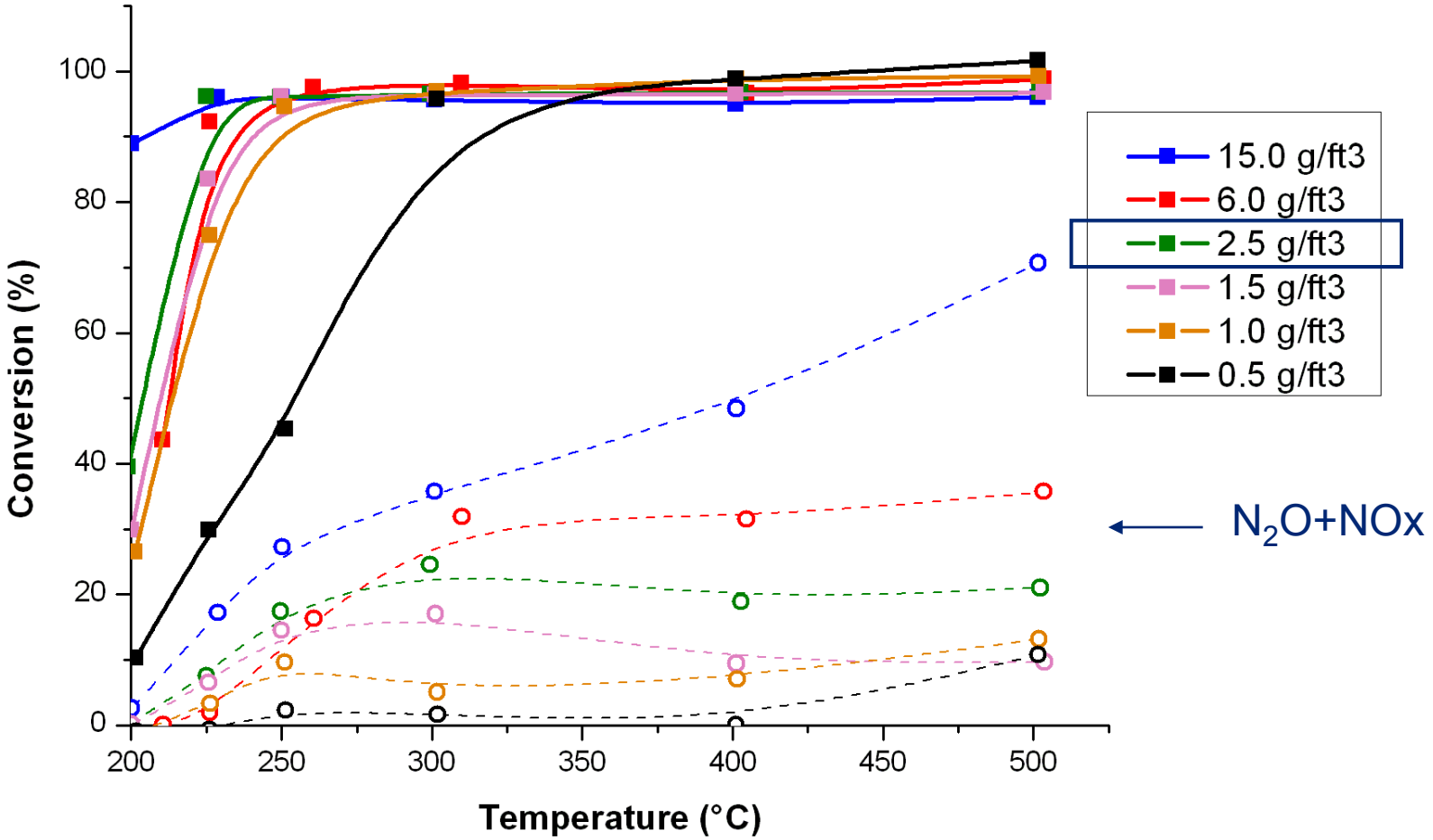
- Ammonia Slip Catalyst
  - High oxidation activity
  - Low formation of N_2O
  - Low formation of NOx
  - Low PGM loading
  - Hydrothermal resistance



Catalyst development

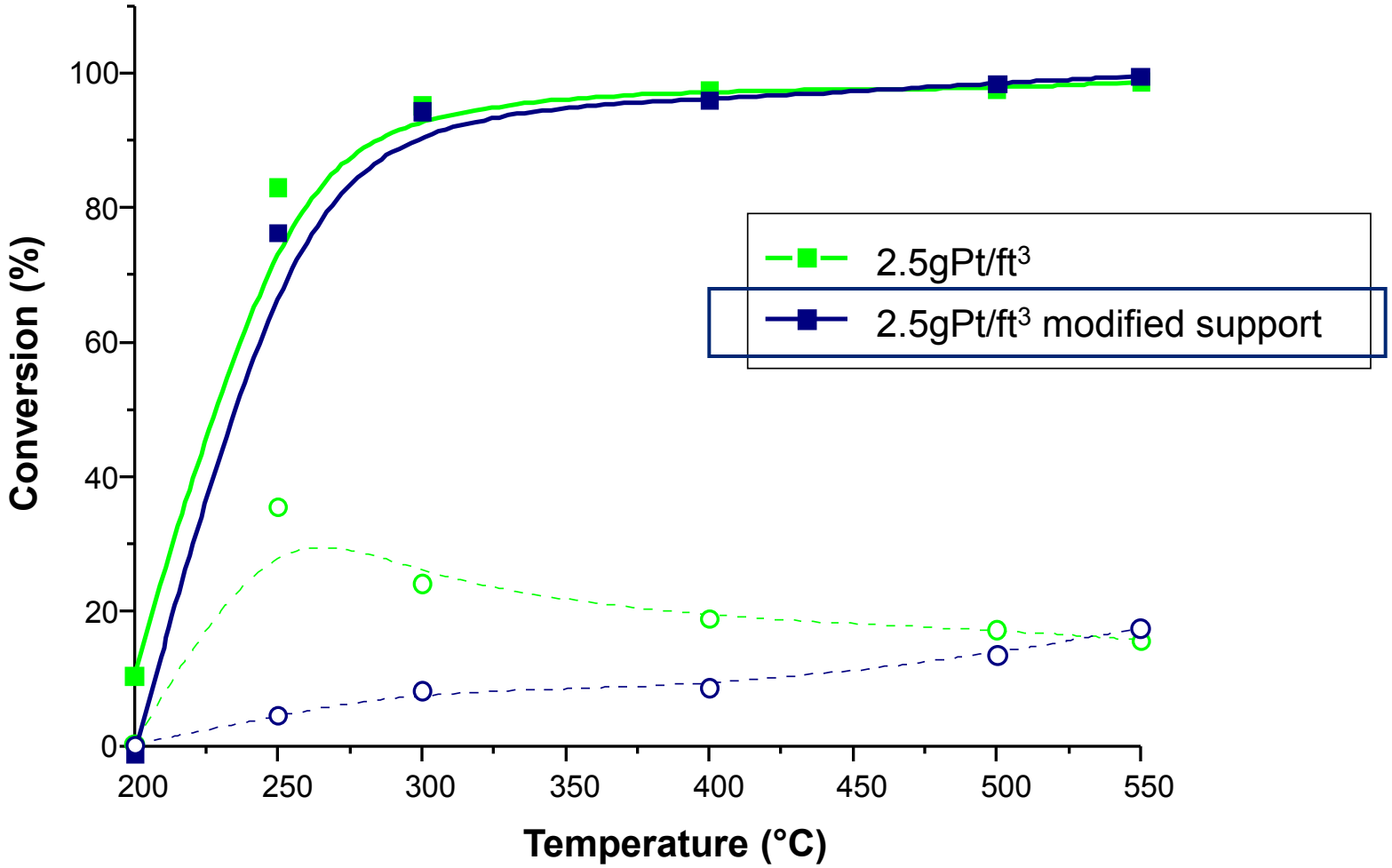
Pt load optimization: Powder tests (40mg)

- 500 ppm NH_3, NHSV=100000h^{-1}, 6% H_2O
- Measuring: NH_3, NOx, N_2O and N_2



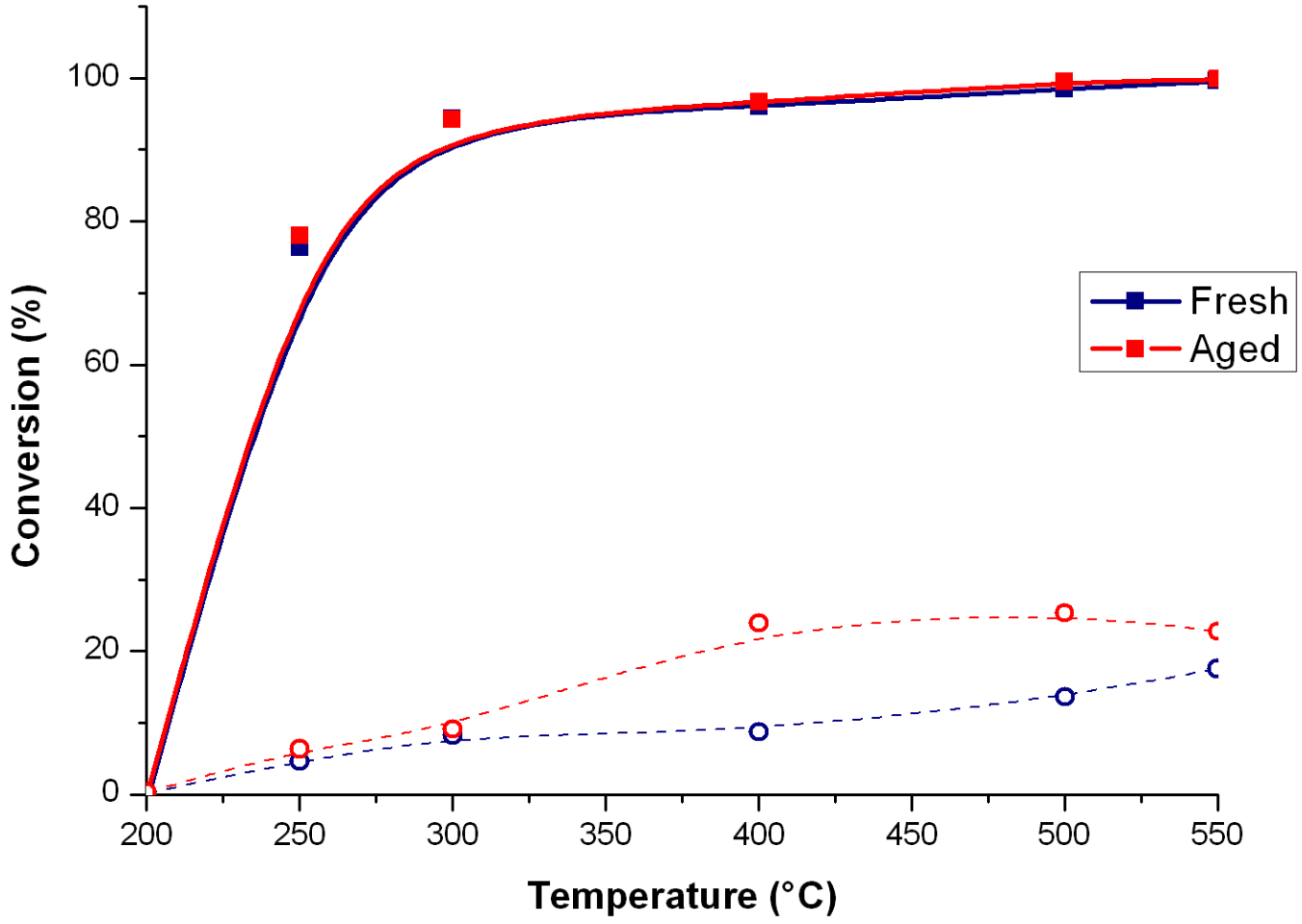
Support modification: Small monolith test (D: 2'', H:3'')

- 200 ppm NH_3, NHSV=100000h^{-1}, 4% H_2O
- Measuring: NH_3, NOx, N_2O



Effect of Ageing (16h @550°C) – small monolith test

- 2.5g/ft^3 Pt, modified support



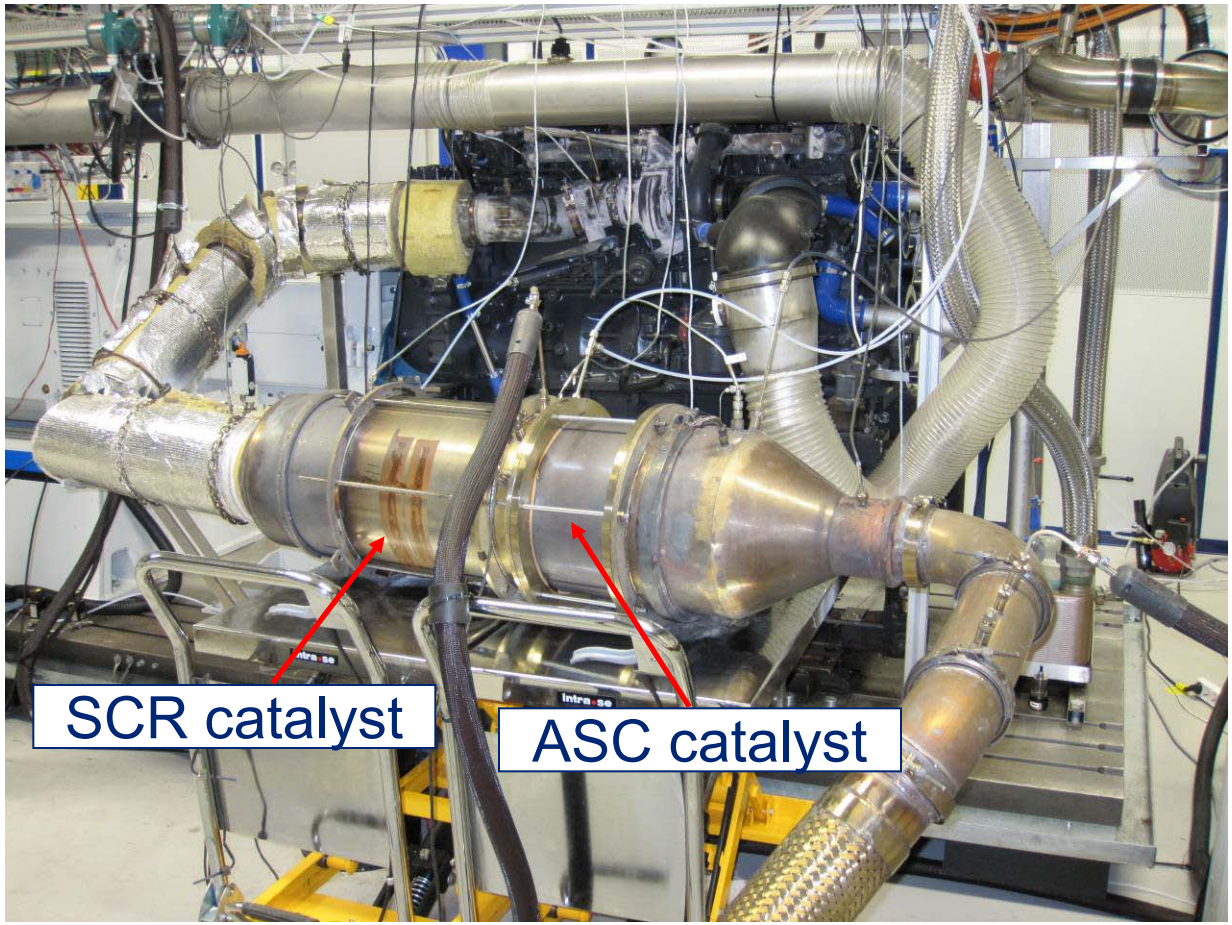
Catalyst development conclusions

- Ammonia oxidation activity is proportional to the Pt load.
- A good compromise between activity and cost is achieved at Pt load of 2.5g/ft^3.
- Modification of support improves the selectivity without significant loss of the oxidation activity.
- Catalyst is hydrothermally stable.

Engine Tests: Experimental setup

- HDD 12L engine
  - Scania D12-13 L01 EUROIV
  - Disabled EGR

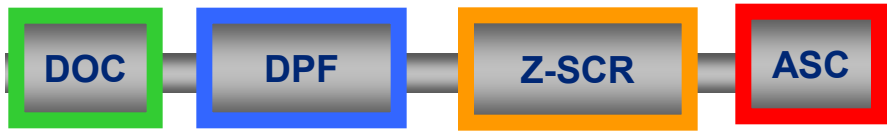
	NOx [g/kWh]
WHTC	12
NRTC	13.8
ETC	9.5



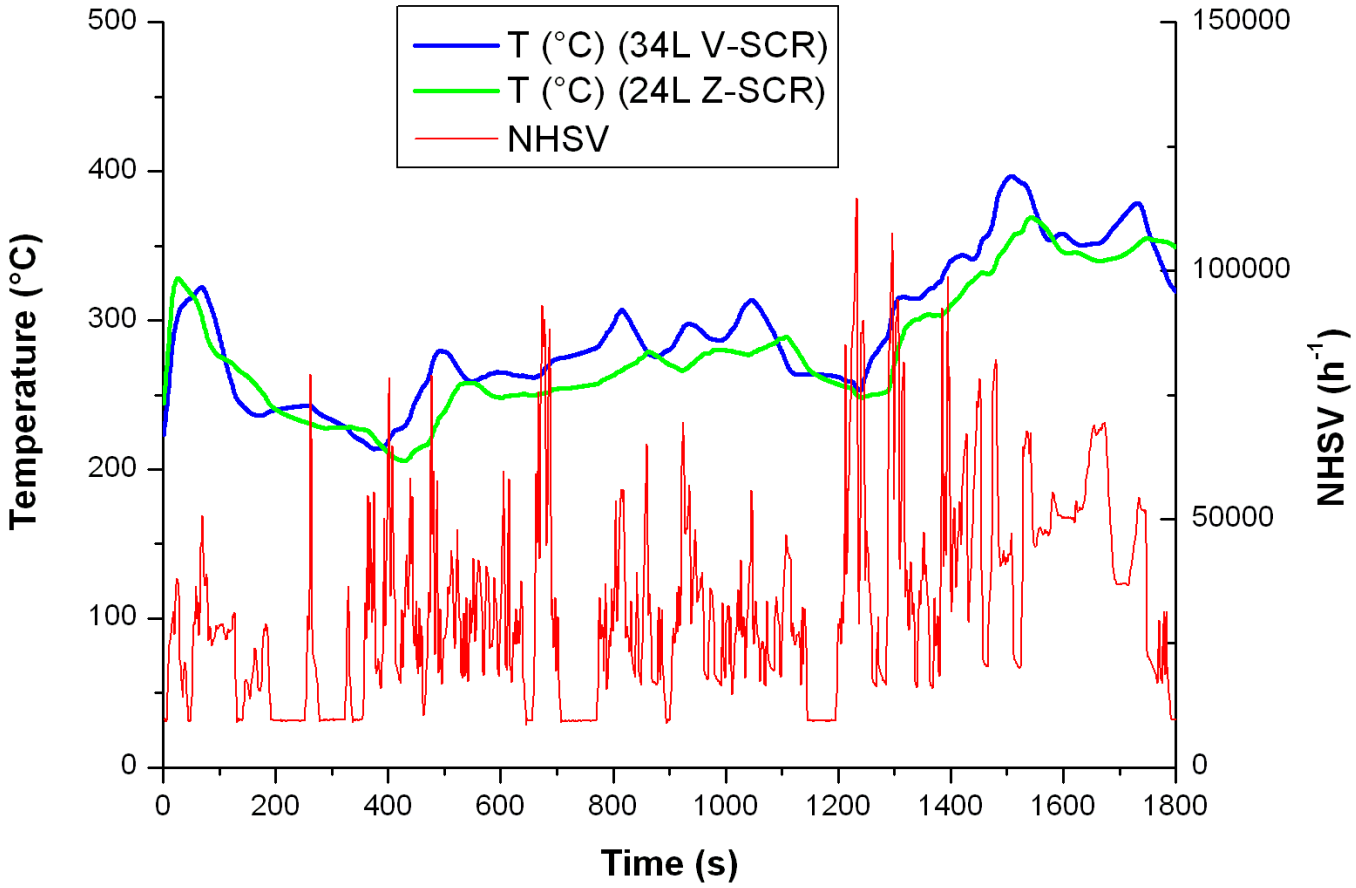
Engine Tests: 12L ASC

- Test protocols
  - World Harmonized Transient Cycle (WHTC)
  - Non-Road Transient Cycle (NRTC) – cold and warm
- Dosing strategies
  - Constant ANR, sweep between 0.7 – 1.2
  - Overdosing algorithm
- Configurations tested
  - 34L VSCR + 12L ASC

  - 10L DOC + 17L DPF + 24L ZSCR + 12L ASC

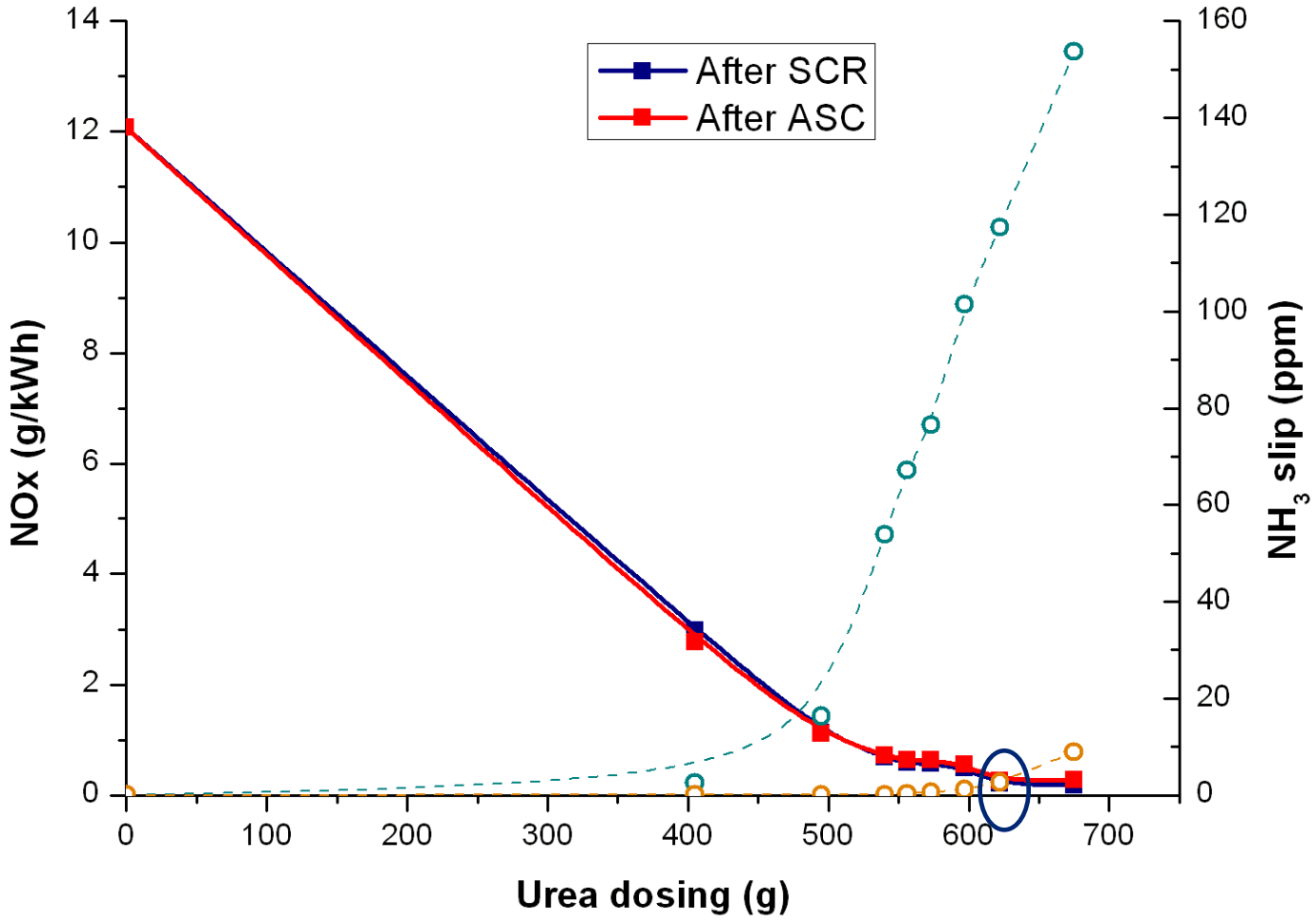


WHTC. Space velocity and temperature

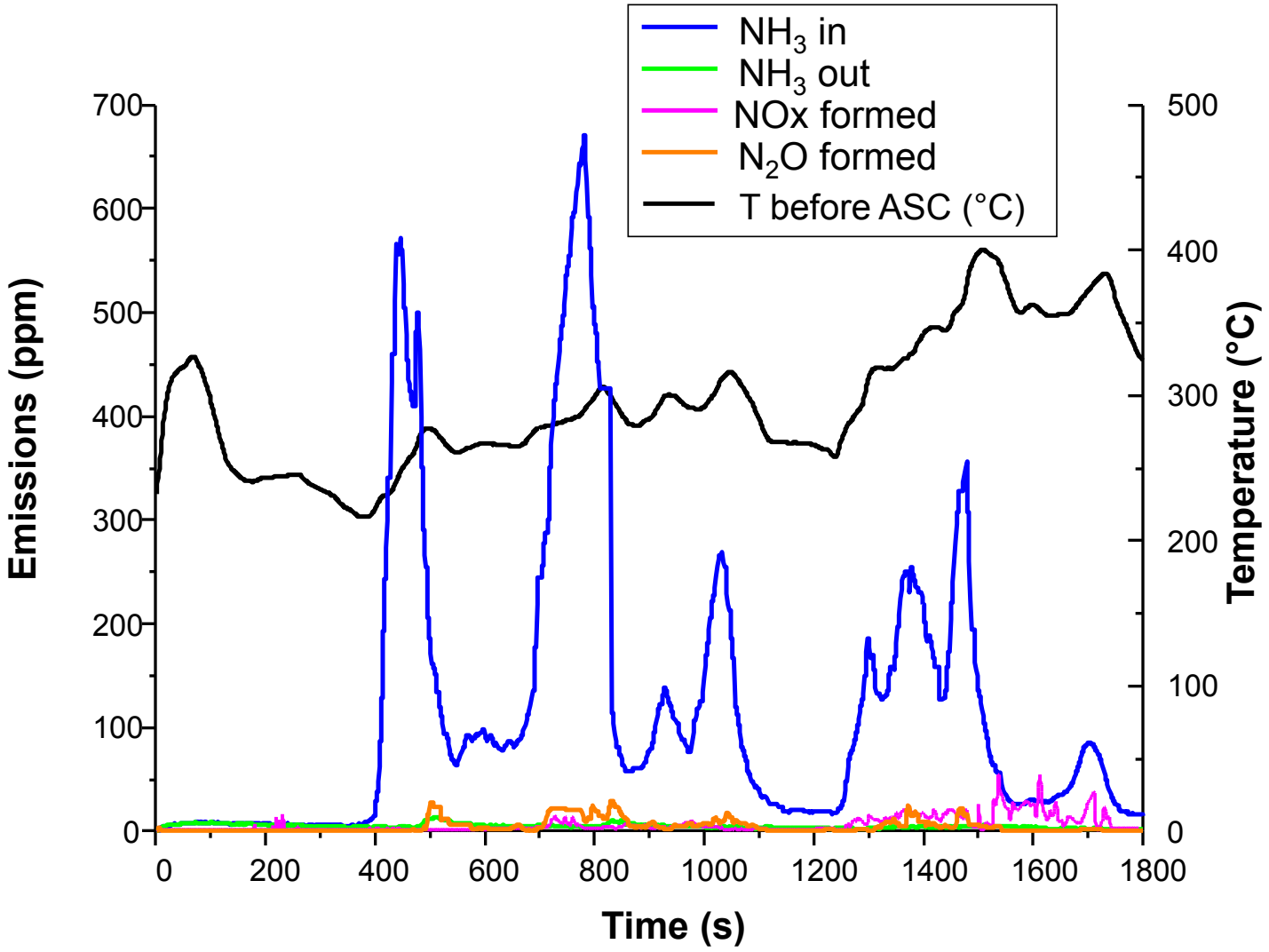


- Average NHSV = 32000 h^{-1}

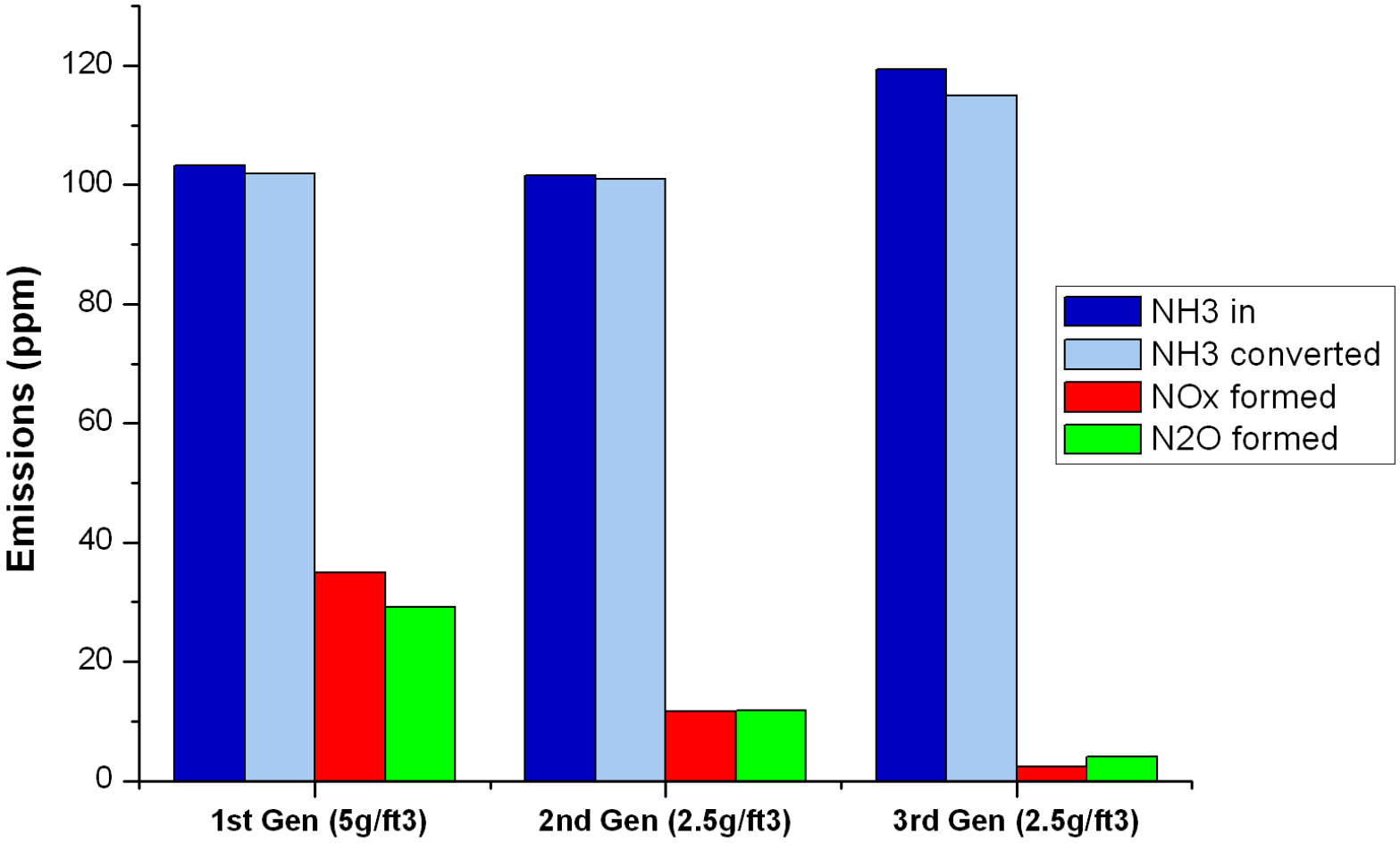
WHTC. Results of ANR sweep



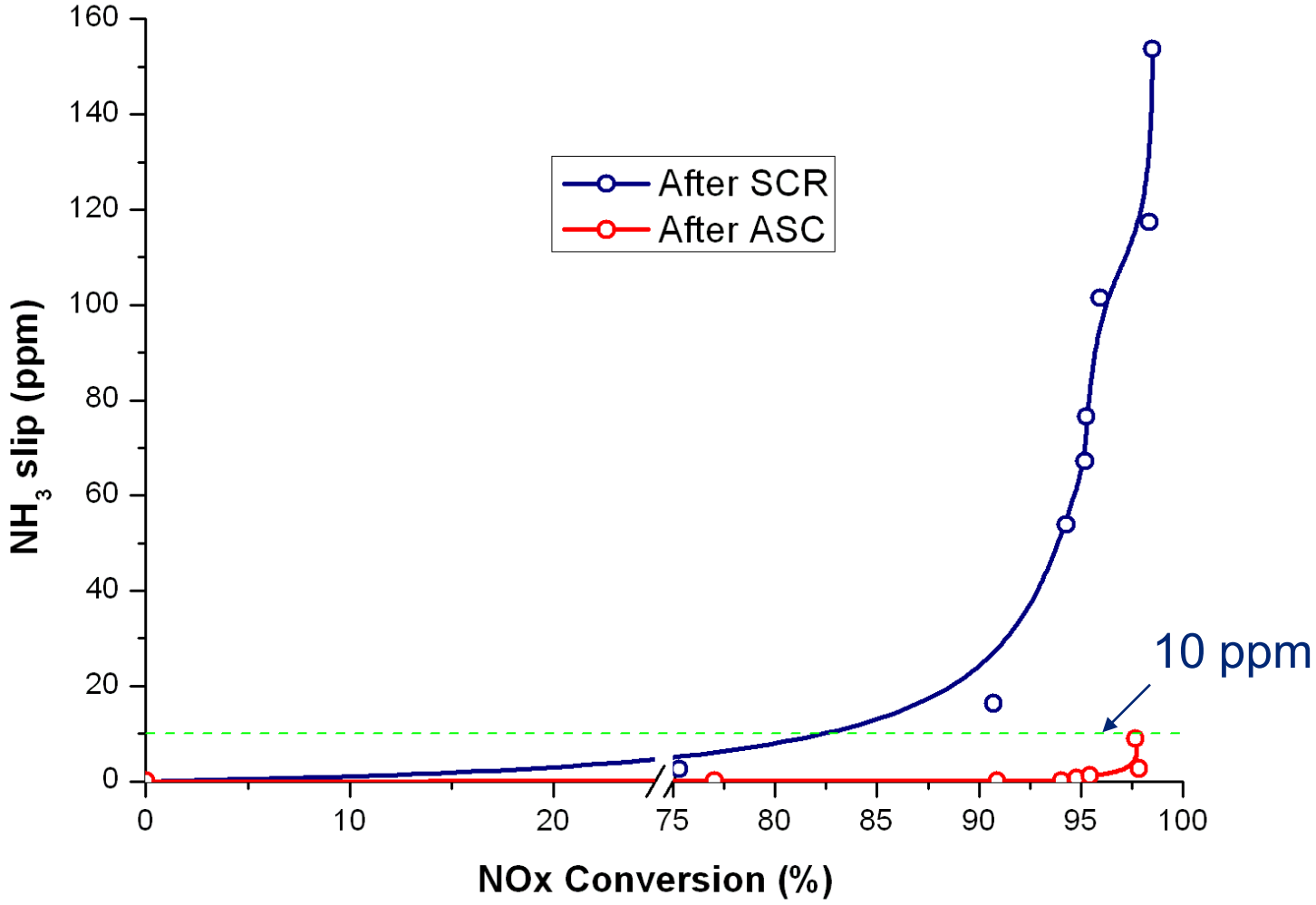
Example of WHTC result



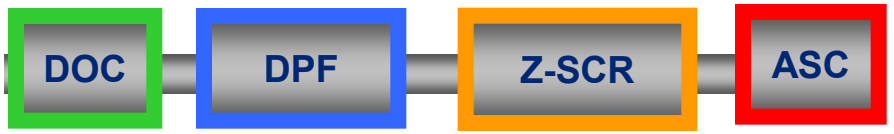
WHTC. Comparison with previous formulations



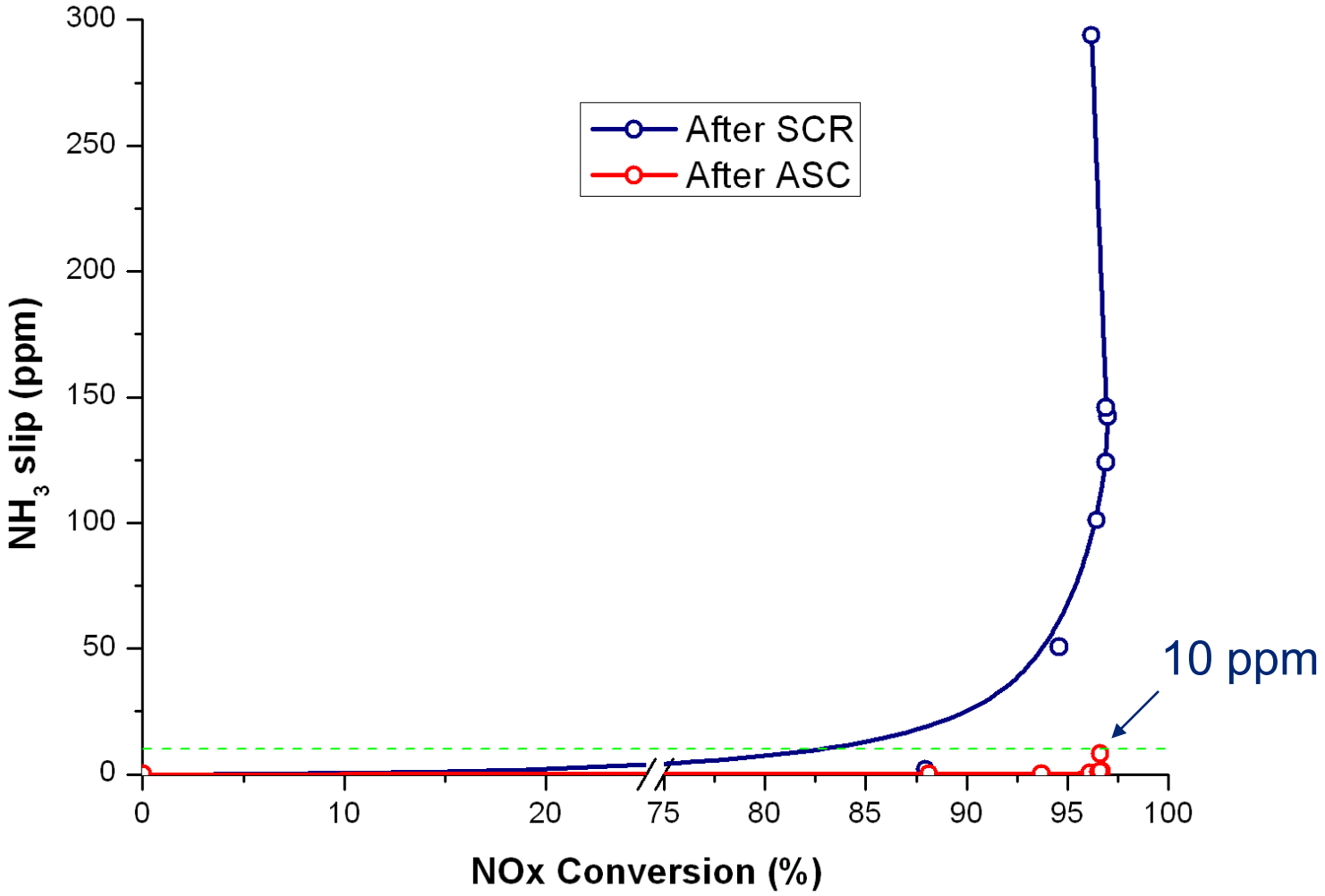
WHTC. Overall system performance



- 97% NOx removal at <10ppm NH_3 slip (10% increase from SCR only)

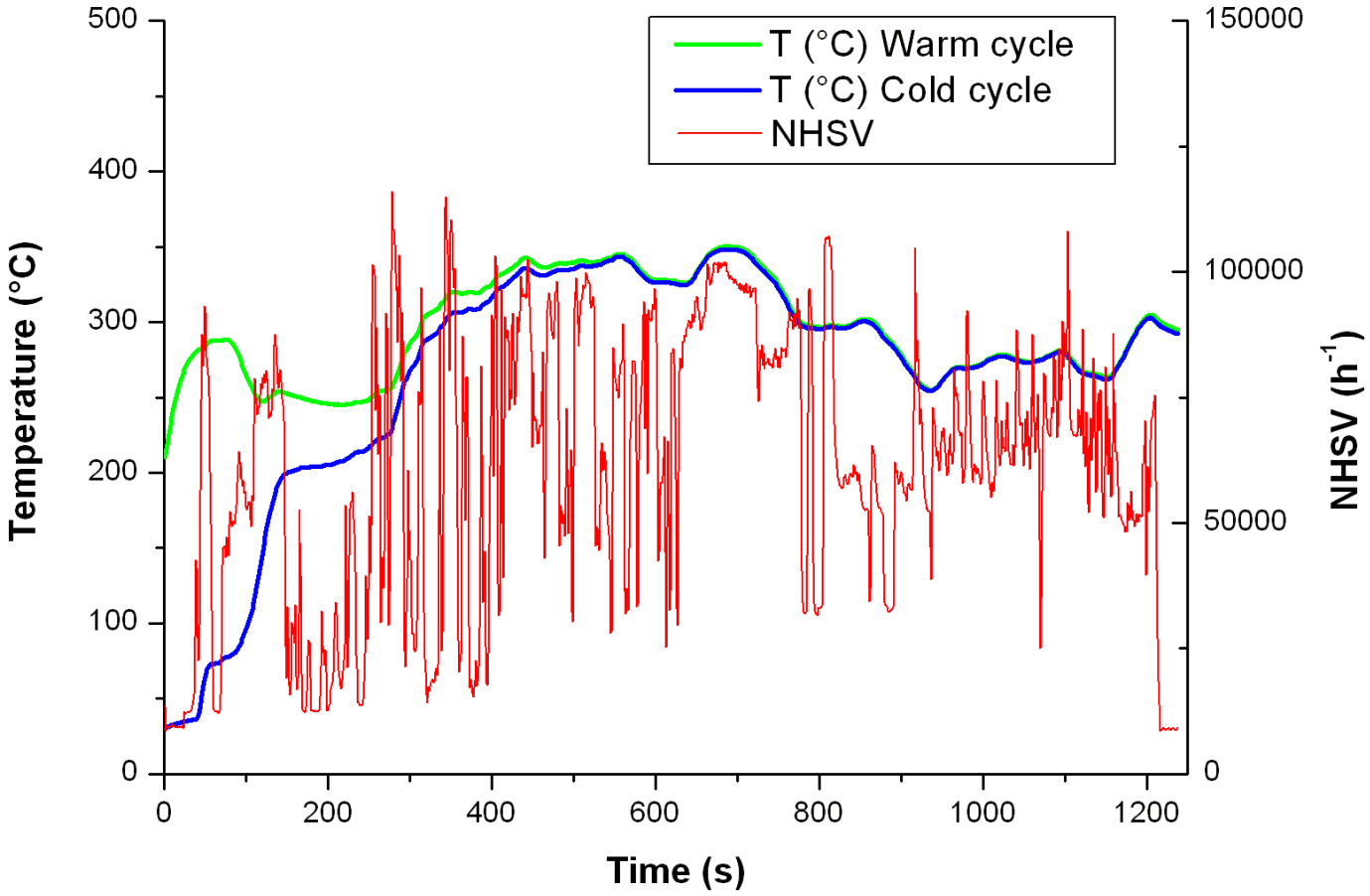


WHTC. Overall system performance



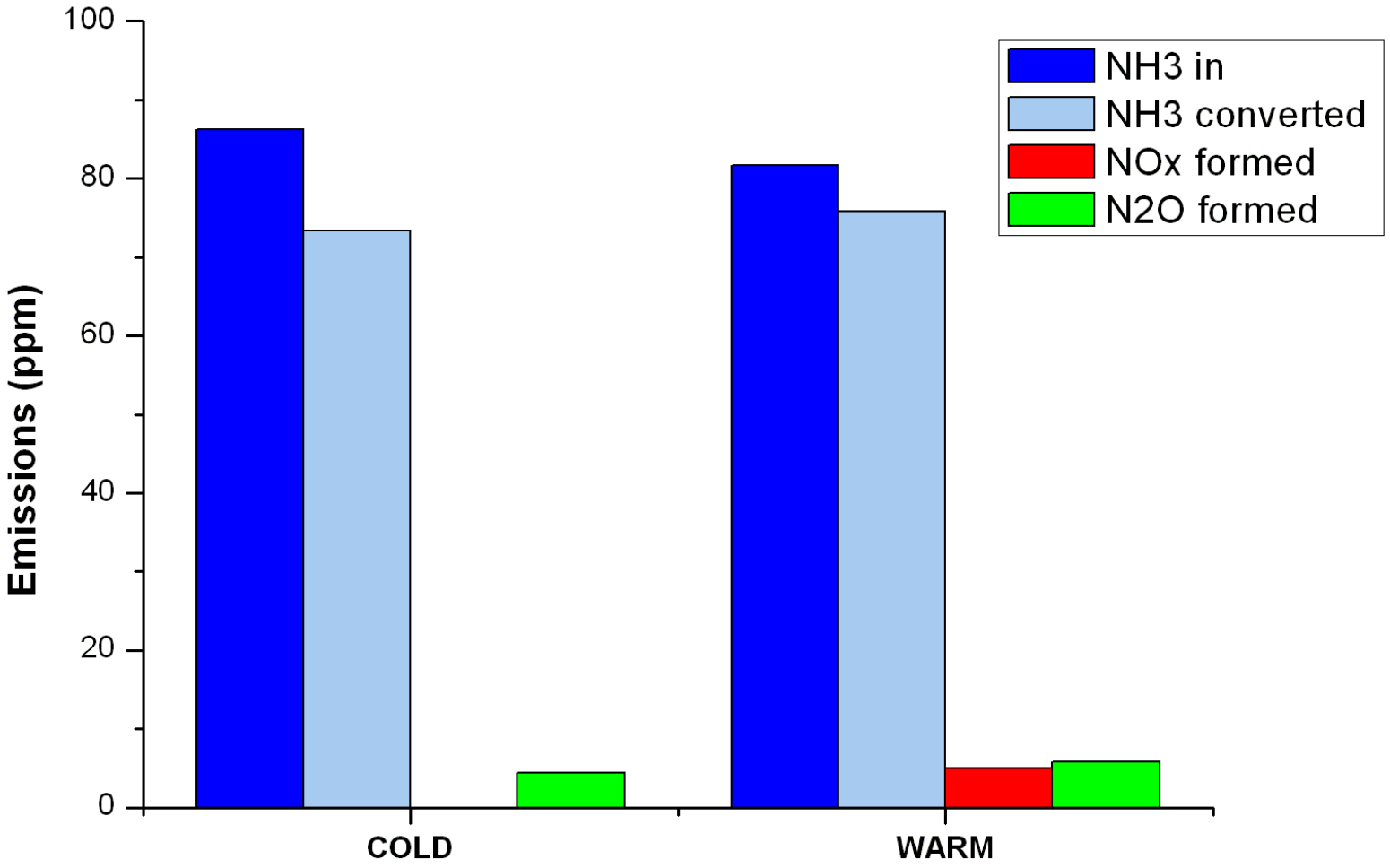
- Similar ASC performance regardless of the system configuration

NRTC. Space velocity and temperature



- Average NHSV = 61000 h^{-1}

NRTC. Cold and warm cycle performance

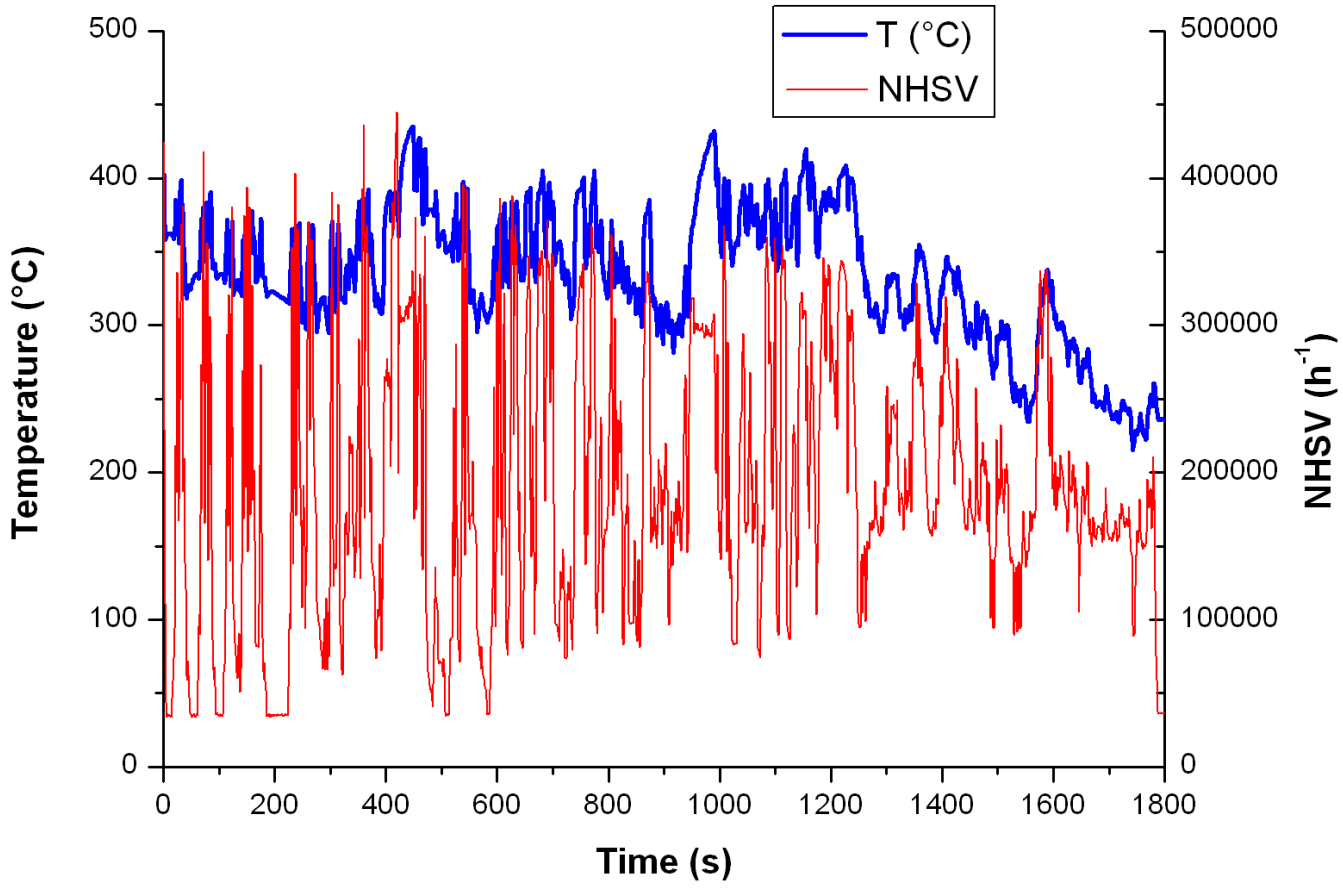


Engine Tests: 3L ASC

- Test protocols
  - European Transient Cycle (ETC)
- Dosing strategies
  - Constant ANR, sweep between 0.7 – 1.2
  - Overdosing algorithm
- Configurations tested
  - 22L VSCR + 3L ASC

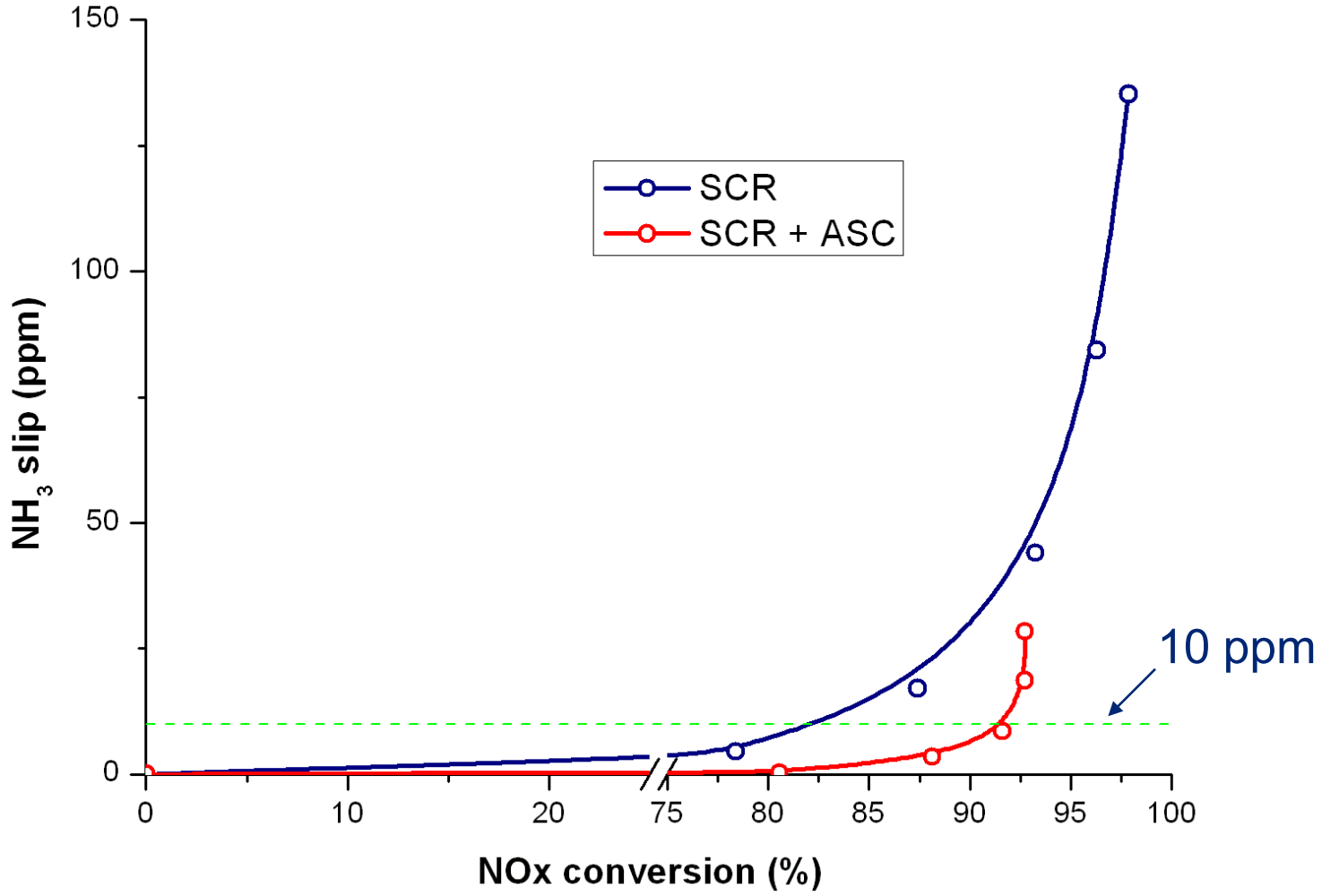
  - 25L VSCR only (for comparison purpose)

ETC. Space velocity and temperature.



- Average NHSV = 190000 h^{-1}

ETC. Overall system performance



- 92% NOx removal at <10ppm NH_3 slip (10% increase from SCR only)

Concluding remarks

	Engine out	System out		
	NOx [g/kWh]	NOx [g/kWh]	NH_3 [ppm]	N_2O [ppm]
WHTC (34L VSCR+12L ASC)	12.0	0.3	2.5	6.0
WHTC (34L VSCR only)	*12.0*	*0.2*	*117.0*	*0*
WHTC (24L ZSCR+12L ASC)	11.5	0.4	1.0	10.0
NRTC (34L VSCR+12L ASC)	13.8	0.8	3.5	5.6
ETC (22L VSCR+3L ASC)	9.8	0.8	8.5	4.5

- New ASC enables NOx emissions close to EURO VI at maximum mean 10ppm NH_3 and N_2O

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