Biodiesel and Cold Temperature Effects on Speciated Mobile Source Air Toxics from Modern Diesel Trucks

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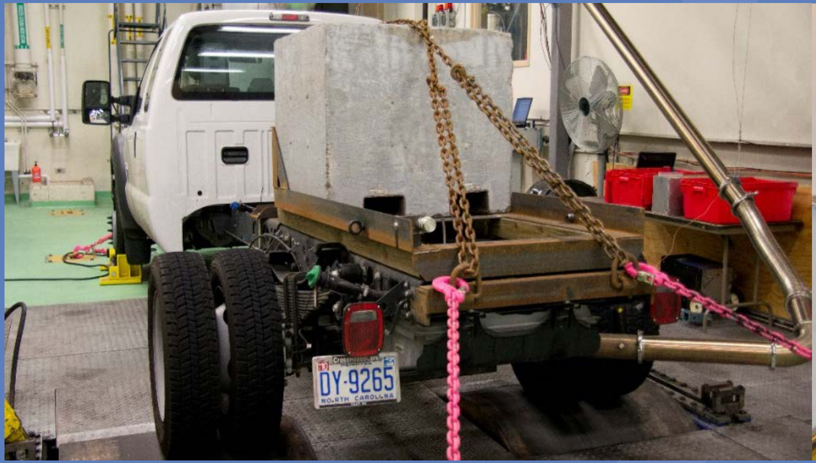

CRC Mobile Source Air Toxics Workshop
Sacramento, CA
Feb. 18, 2015

United States Environmental Protection Agency

Background

- 2007 Heavy-Duty Highway Diesel Rule mandated full compliance of the new emission standards by 2010
- U.S. Energy Independence and Security Act required the increase in usage of renewable biofuels to 36 billion gallons by 2022
- The impact of 2010+ aftertreatment technologies and biodiesel on mobile air toxics emissions from modern HD diesel truck is not well understood, **especially at cold temperatures**
- **Objective: To measure speciated emissions from modern HD trucks operating on diesel and biodiesel under cold temperature conditions**

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Test Vehicles: LHDDT/MHDDTs

Dodge Ram 2500 (Class 2B)
MY 2011
ODO = 22,062 miles
GVWR = 9,600 lbs
NAC/DOC/DPF

Ford F550 (Class 5)
MY 2011
ODO = 2,693 miles
GVWR = 19,500 lbs
SCR/DOC/DPF

Ford F750 (Class 6)
MY 2011
ODO = 3,636 miles
GVWR = 25,999 lbs
SCR/DOC/DPF

Test Conditions

Fuels

- Ultralow sulfur diesel (ULSD)
- 20% soy biodiesel blended with ULSD (B20)

Temperature

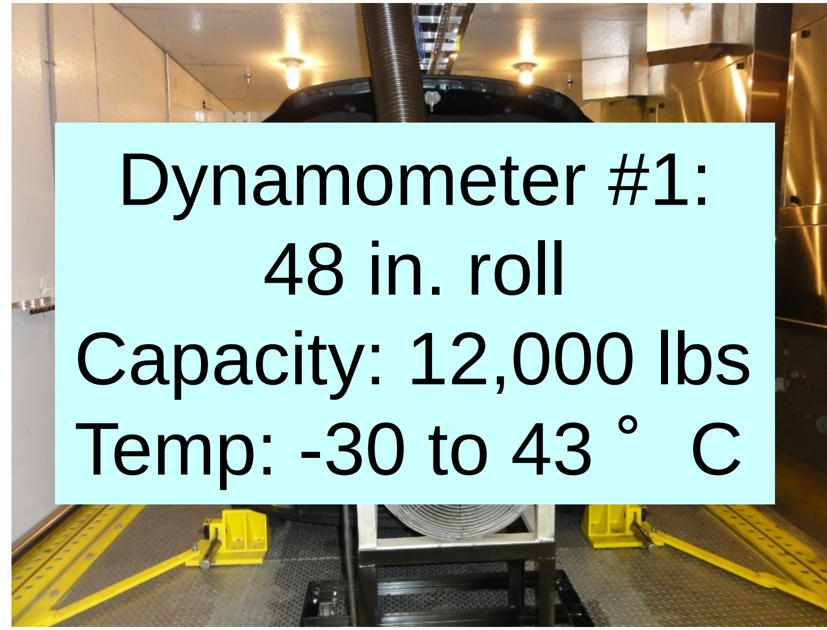
- -7 ° C
- 22 ° C

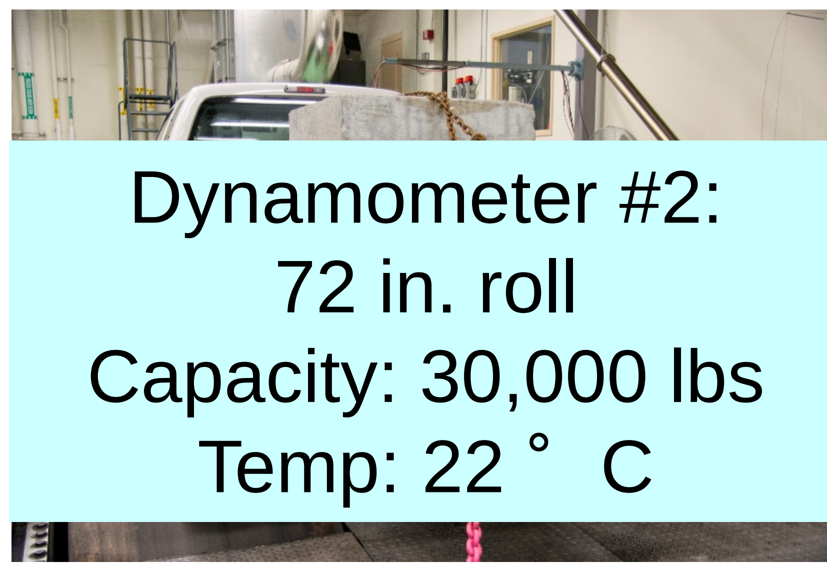
Test vehicle weight

- unladen
- laden (90% GVWR)

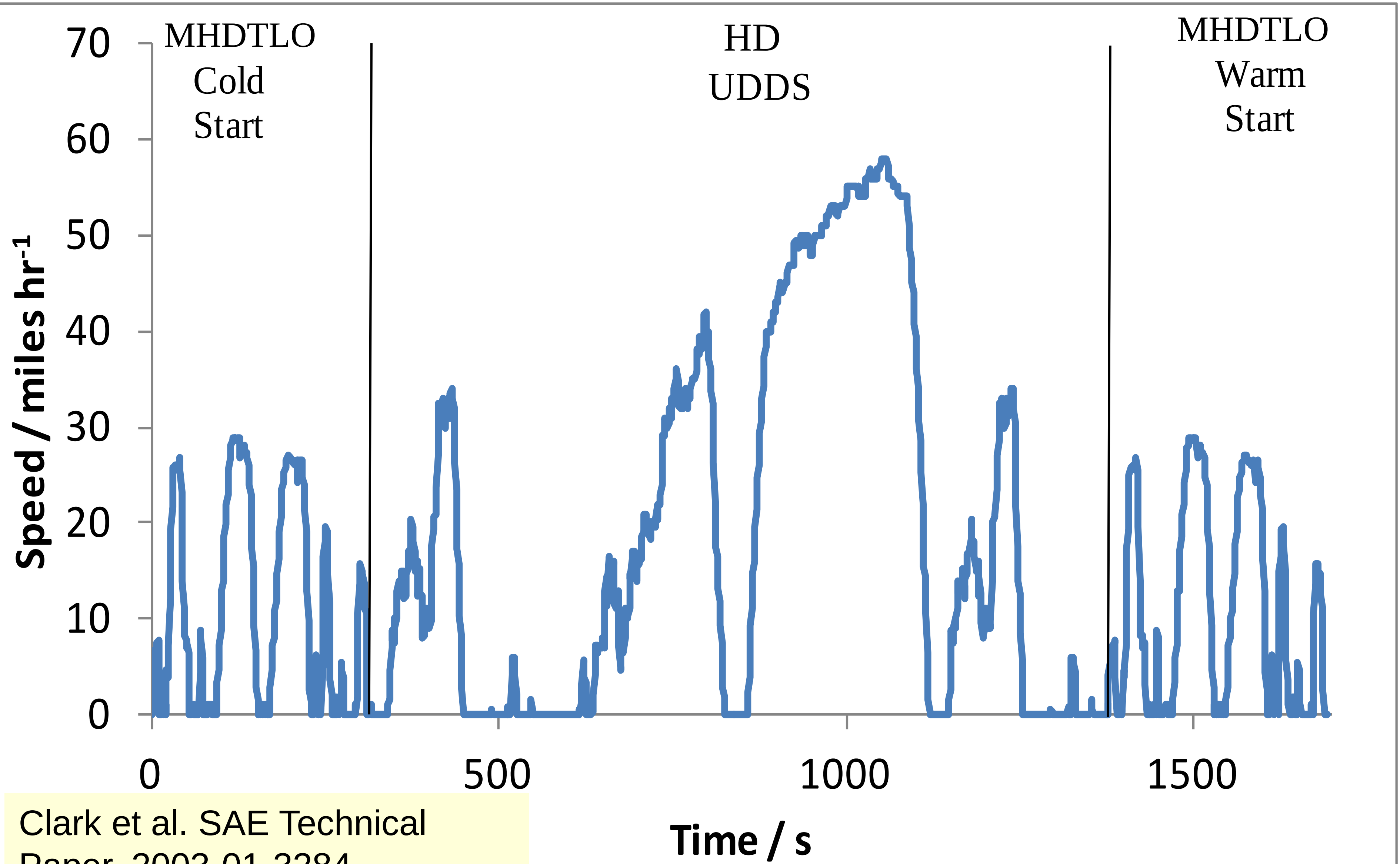
Aftertreatment

- NAC, DPF regenerations



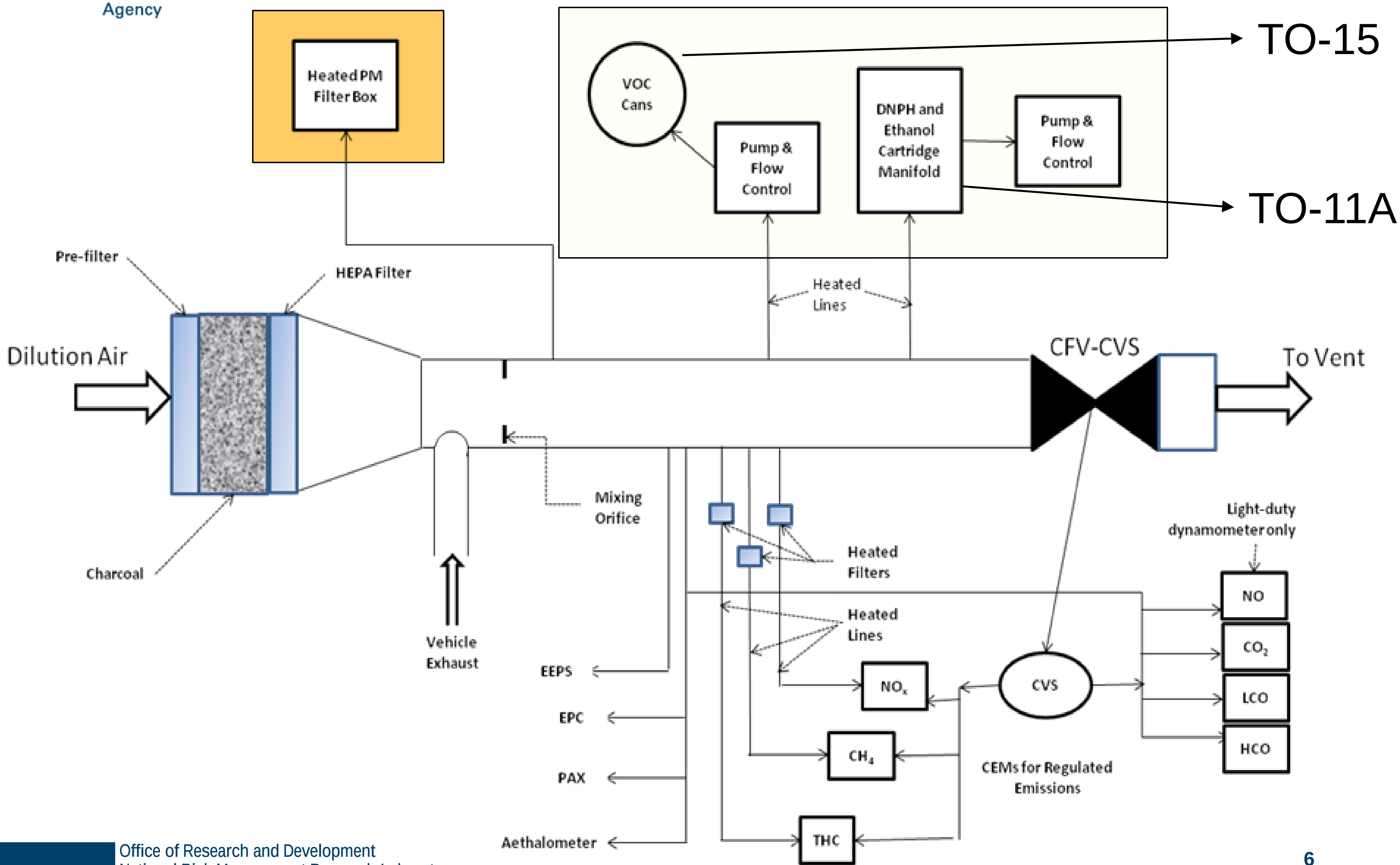


Driving Cycle

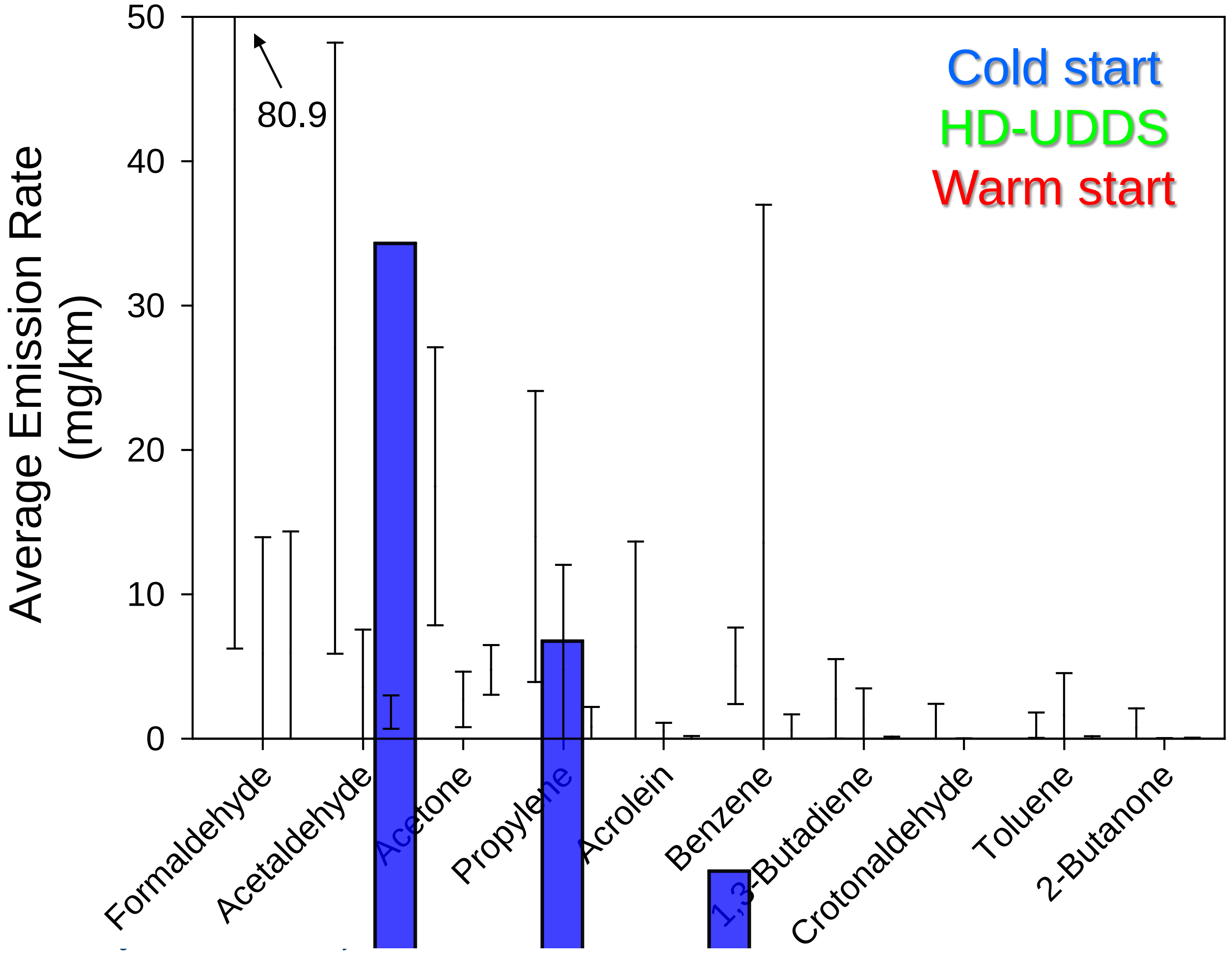


Clark et al. SAE Technical Paper, 2003-01-3284

Dilution Tunnel and Sampling



Results: VOC profiles

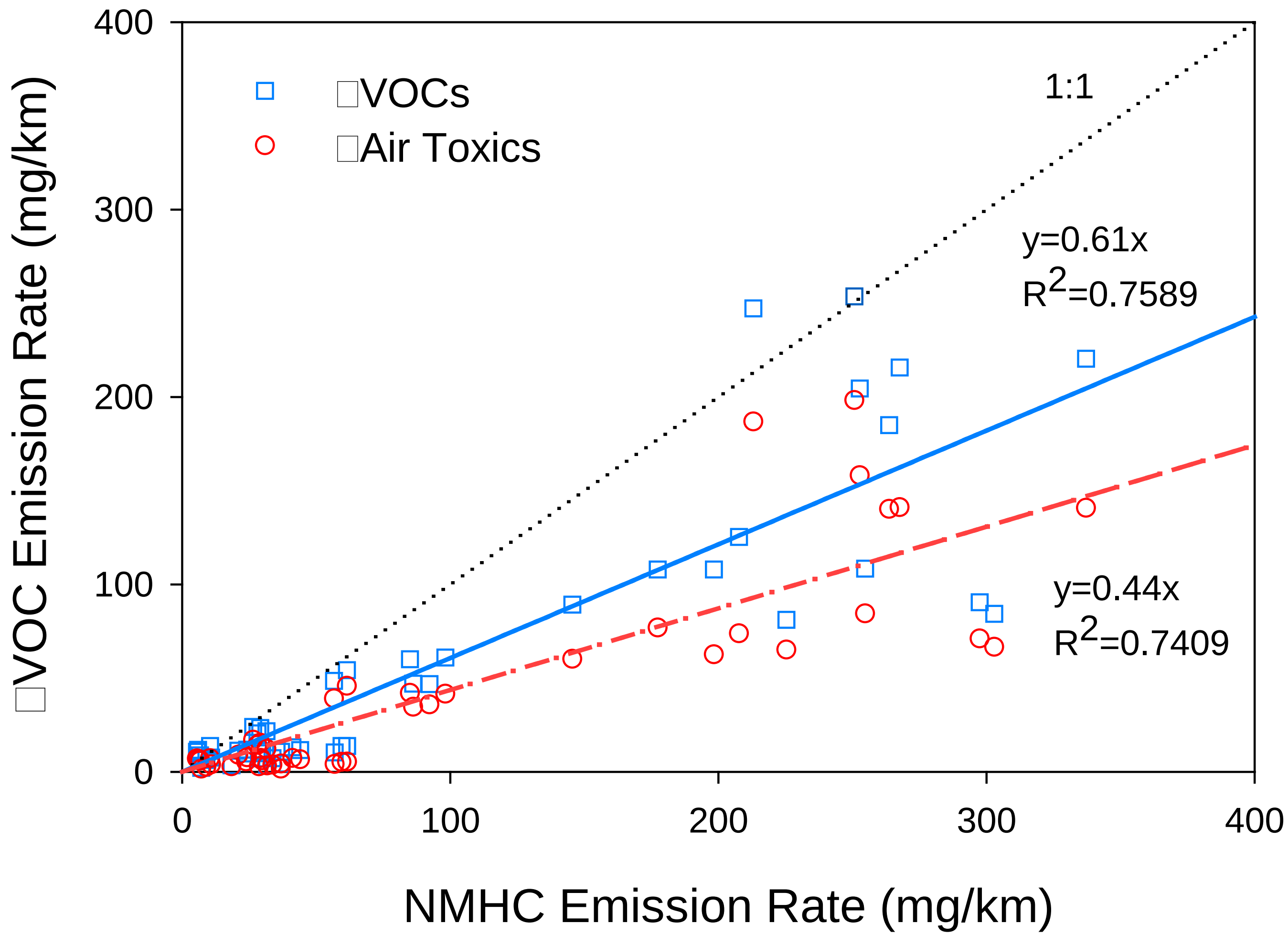


MSATs and NMHC comparison

MSATs were 71% of speciated VOC emissions

<u>Air toxics (R^2)</u>

Formaldehyde (0.36)
Acetaldehyde (0.48)
BTEX (0.24-0.56)
Acrolein (0.41)
1,3-Butadiene (0.78)
Styrene (0.30)
Naphthalene (0.39)
n-Hexane (0.06)



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Speciated ΣVOCs

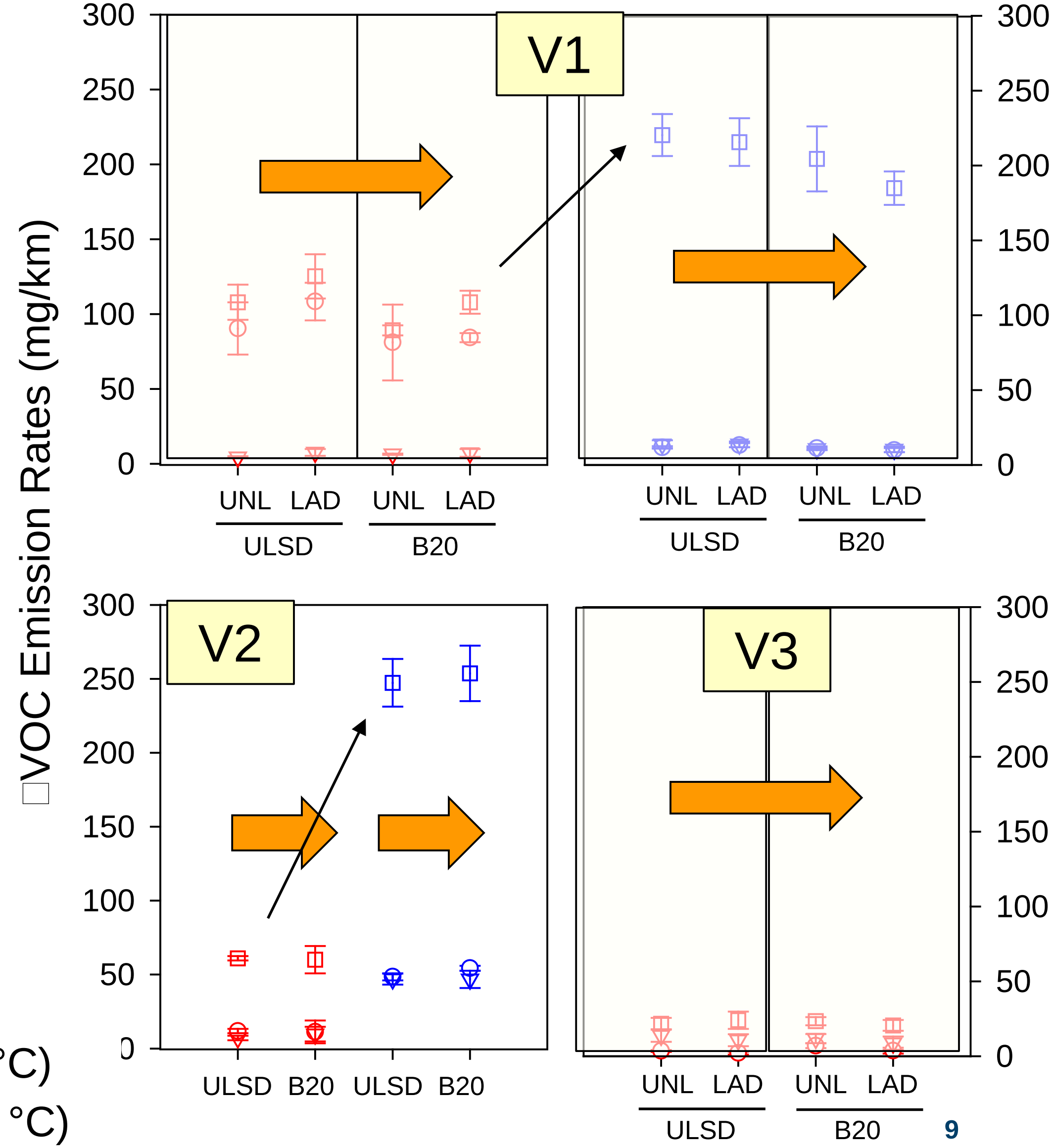
22° C
-7° C

ΣVOC rates varied by vehicle (e.g. V1 HD-UDDS and V3 cold start)

VTW did not affect ΣVOCs

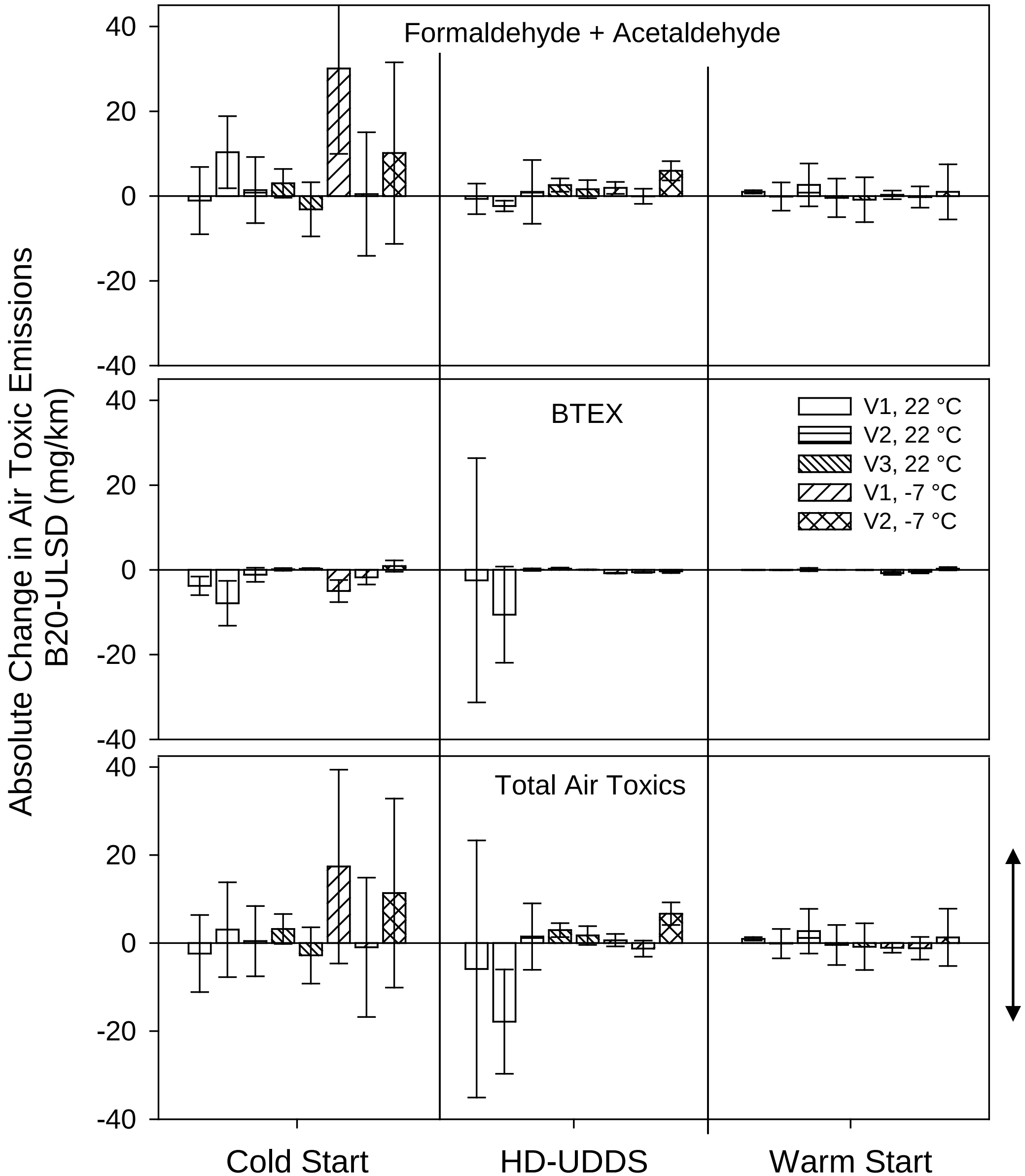
B20 fuel had minor effects

Driving cycle and temperature were the most important factors



□ Cold Start (22 °C)
○ HD-UDDS (22 °C)
▽ Warm Start (22 °C)

Fuel Effects on MSATs

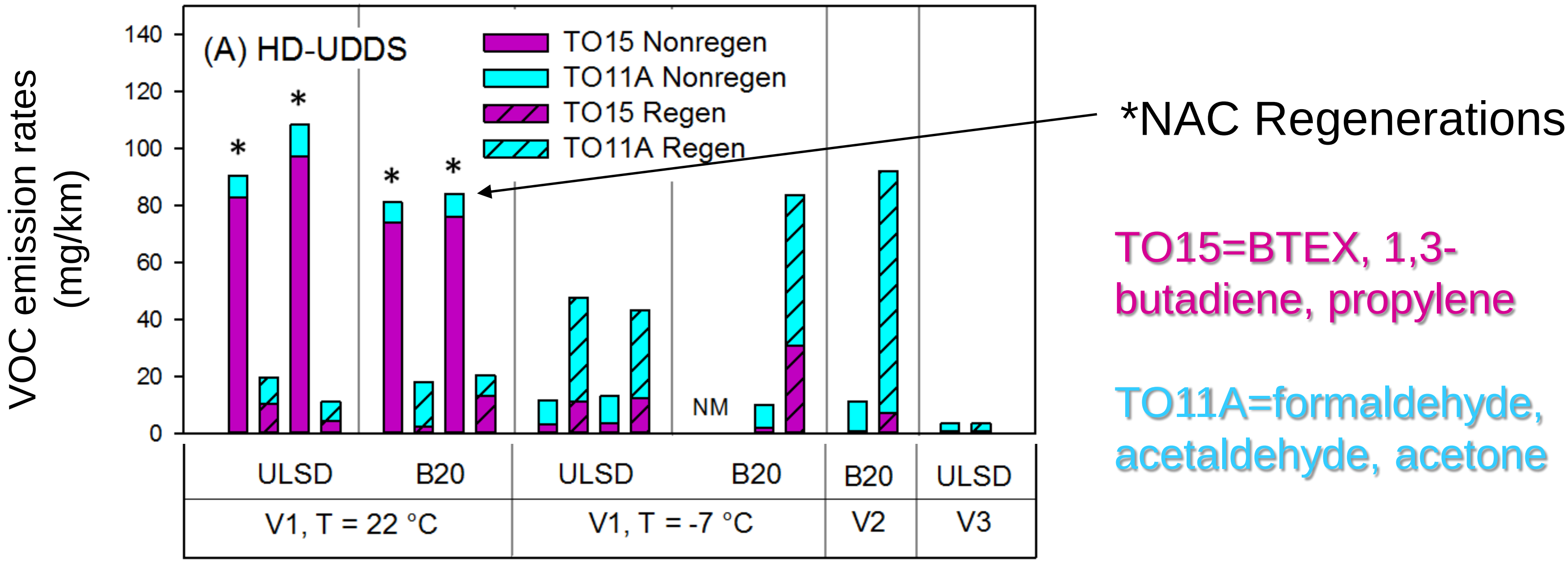


Carbonyls increased with B20 use but changes were variable

Significant decreases in BTEX for V1

Overall changes in MSATs were ±18 mg/km

DPF Regeneration

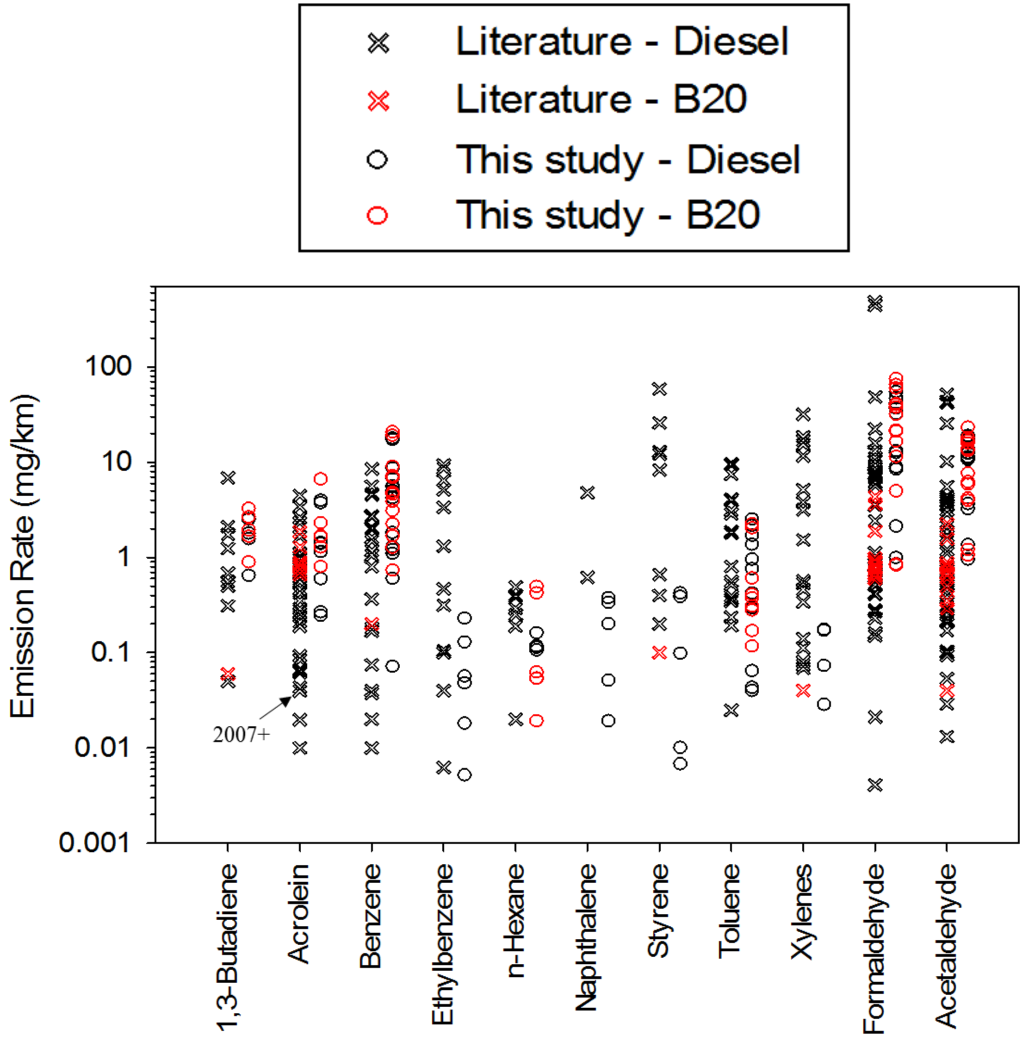


TO15=BTEX, 1,3-butadiene, propylene

TO11A=formaldehyde, acetaldehyde, acetone

- For V1 at 22° C: *NAC* vs DPF regens affects BTEX (TO15)
- DPF regens increased VOCs, esp. carbonyls for other tests

Literature comparison



Average ERs
This work (22C) / Lit.

MSAT	Diesel	B20
1,3-Butadiene	0.41	11
Acrolein	1.2	1.5
Benzene	3.4	28
Ethylbenzene	0.011	-
n-Hexane	0.14	-
Naphthalene	0.024	-
Styrene	0.0041	-
Toluene	0.23	-
Xylenes	0.0053	-
Formaldehyde	3.9	23
Acetaldehyde	0.41	14

References:
Cahill et al., 201…
Caplain et al., 2006.
Fontaras et al., 2009.
Fontaras, et al., 2010
Kado et al., 2…
Karavalakis … 9a.
Karavalakis … 9b.
Karavalakis … 0.
Macor et al., …
Montero et a…
Nelson et al., 2008.
Schauer, et a…
Siegl et al., 1999.
Tsai et al., 2012.

Summary

- Cold start and colder temperature dramatically increased air toxics, esp. carbonyls
- Soy B20 usage led to minor reduction in aromatics and variable increases in carbonyls
- NAC and DPF regenerations modified air toxic emissions that were compound and condition specific
- Modern HD trucks in this study had reduced MSAT emissions of aromatics, but not carbonyls, compared to older diesel vehicles

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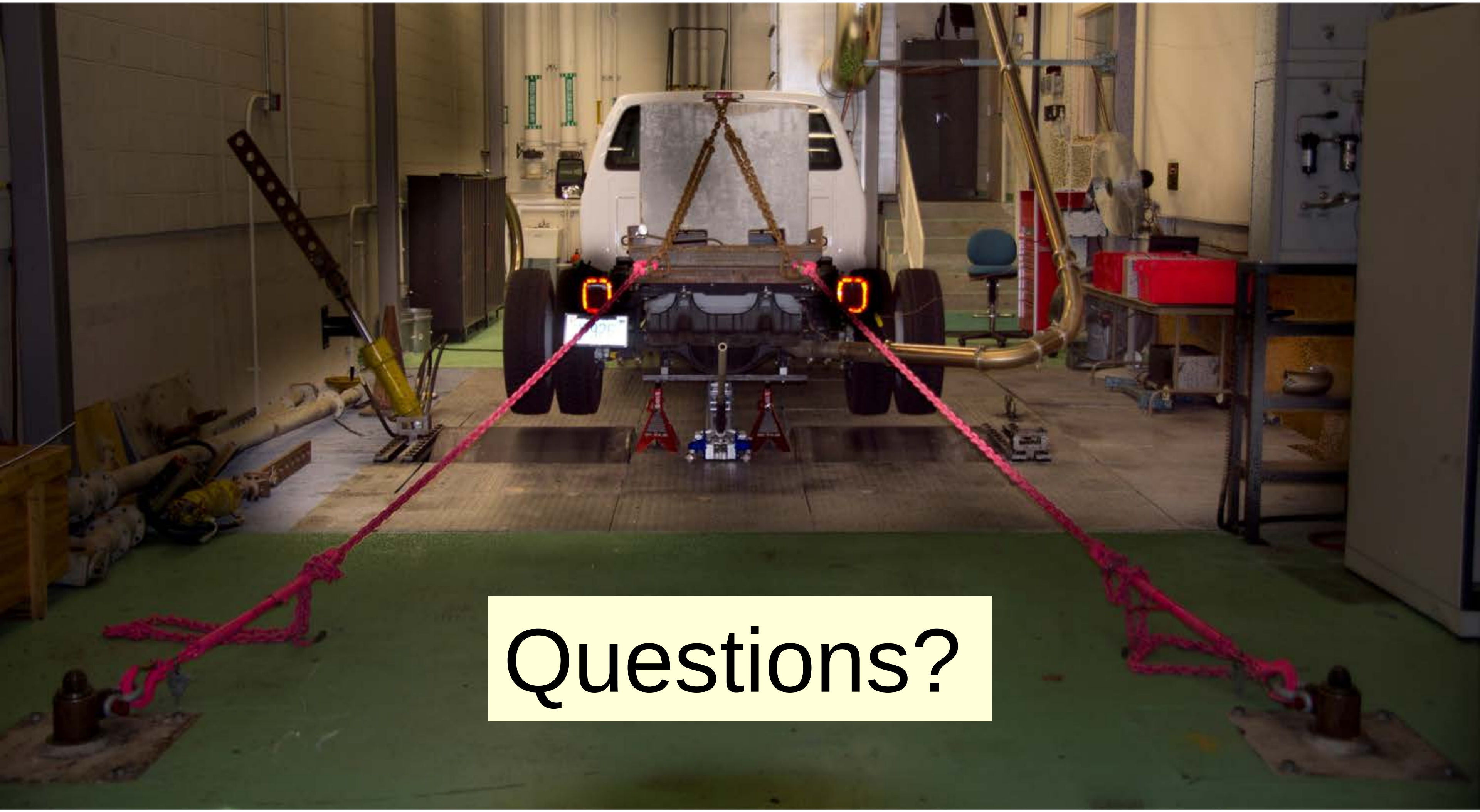

Reference: George et al., ES&T 2014.