Real driving emissions from a diesel-hydraulic rail vehicle

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Background: **Real driving emissions** are often higher than those during laboratory certification tests as they include conditions for which some engines are not optimized. They are monitored on heavy on-road vehicles in the EU and U.S., with likely extension to non-road mobile machinery (NRMM).

Testing of **non-road engines over 560 kW** is difficult – there are few laboratories, removing and transporting engines is expensive. Diesel-electric locomotives can be tested at standstill using a load bank; **diesel-hydraulic locomotives need to be moving in order to maintain load on the engine**.

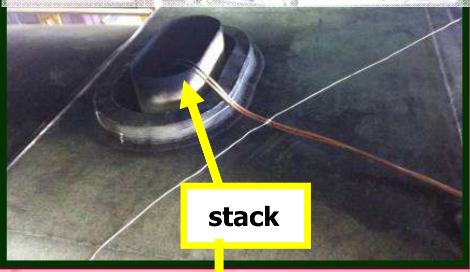
Portable on-board emissions monitoring systems (PEMS) can be used, but surprisingly, given safety and operational constraints, there is not much available space on many types of machinery including rail vehicles.

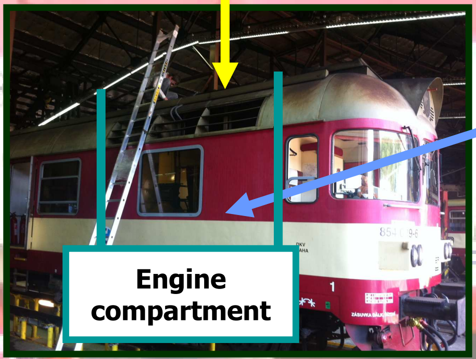
Goal: **Evaluation of real driving emissions of a diesel-hydraulic motorized rail vehicle during its regular service on passenger train routes.**

Approach:

- Czech Railways model 854 motorized railcar with a 2004 12-cylinder, 29-liter, 808 kW (only 588 kW used) Caterpillar 3412 engine (US EPA 0.29 g/kWh PM), with about 1 million km in service, was fitted with a miniature PEMS mounted entirely at the end of the dead-end isle of the engine compartment (no place elsewhere).
- The car was running alone or with up to three non-motorized cars on local and express train routes on the Praha-Turnov route.

Low-profile installation due to overhead traction lines



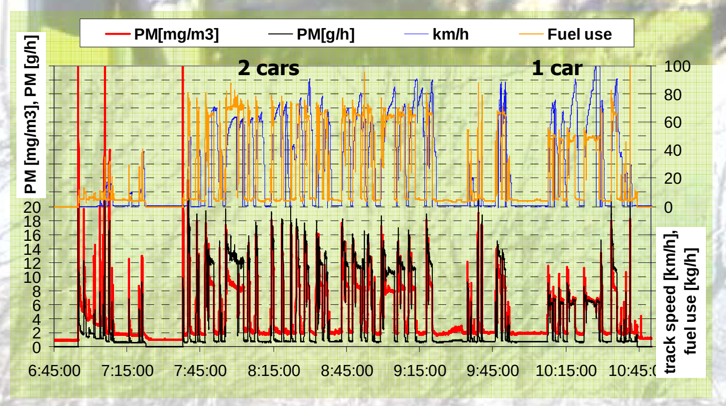


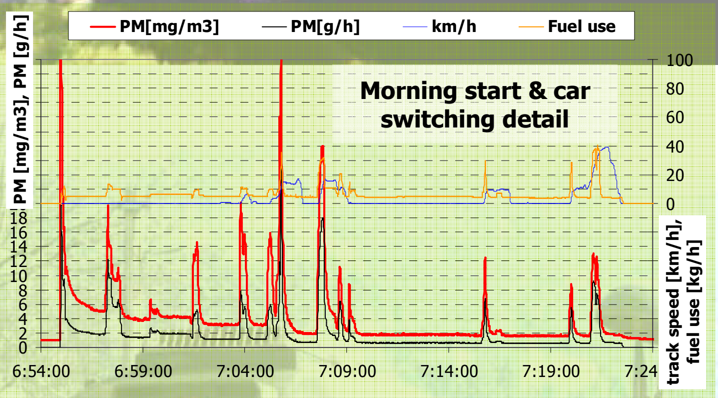
Severe environment: 0-55°C, vibrations, "rail dust" (a mixture of soot, oil, grease, iron oxide brake dust), lack of access during most of the train run

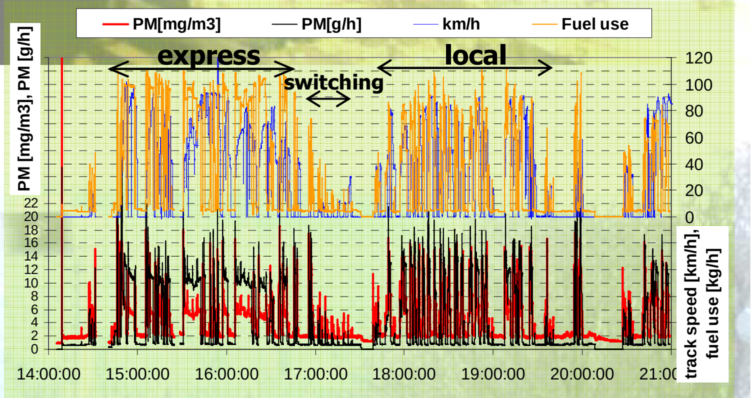
Lack of space: Confinement into "dead-end isle" of engine compartment (nothing can be put outside of the train, no opening to conductor cabin, one isle to remain free for train engineer to walk through during turnarounds).

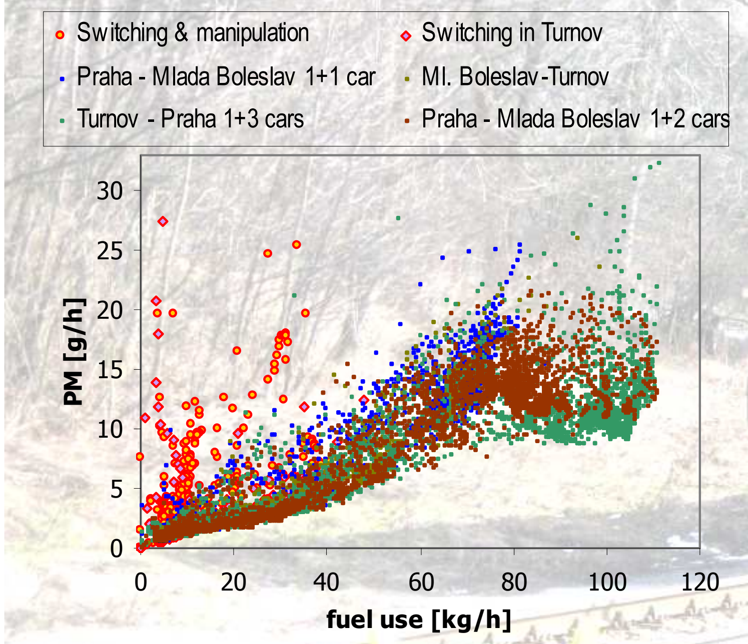
Home-made mini PEMS design

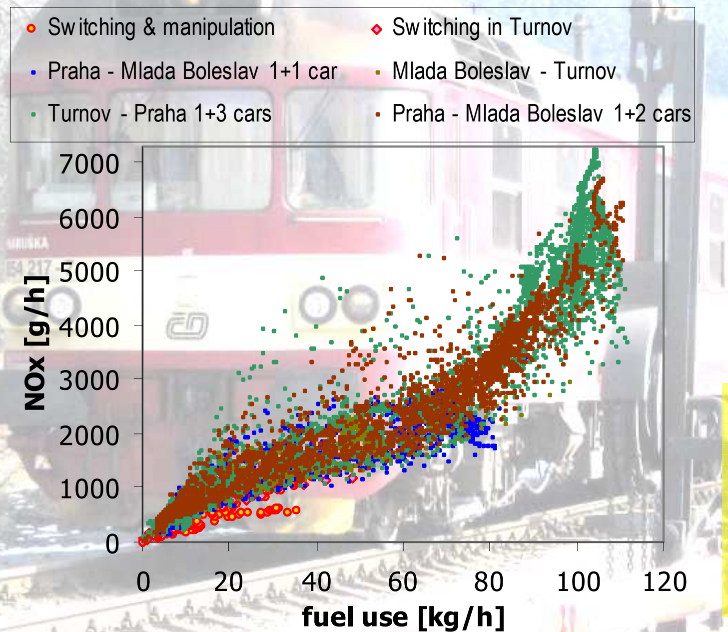
CO, CO2: NDIR - NO, NO2: electrochemical cells
PM mass: proportional sampling gravimetric
Indicative online PM mass: light scattering
Particle length: measuring ionization chamber
Position & speed: GPS
Intake air flow: calculated using speed-density method from measured engine rpm and measured intake air pressure and temperature

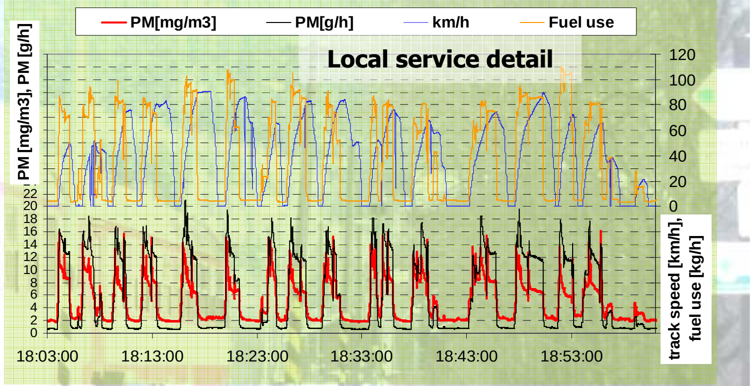












Conclusions:

- Measurement challenging but feasible
- Moderate excess PM at cold start, long idle, transients – otherwise steady-state
- PM exhaust emissions relatively low

Summary data Totals per train	cars	km	Fuel liters per 100 km	PM [g/km]	CO2 [g/km]	CO [g/km]	NO [g/km]	HC [g/km]
All measured segments		303.9	107	0.14	2835	8.2	43	2.0
Start & switching		1.7	212	0.53	5625	22.4	77	3.2
Praha - Mladá Boleslav (Os 9504)	1+1	71.6	94	0.15	2483	8.9	31	0.8
Mladá Boleslav - Turnov	1+0	32.8	85	0.11	2248	9.7	33	1.6
Turnov - Praha (express R 1145)	1+3	103.6	125	0.14	3321	5.9	55	2.5
Praha - Mladá Boleslav (Os 9514)	1+2	74.9	107	0.14	2836	9.5	42	2.4

Emissions per passenger-km assuming 25% occupancy (Czech national average train occupancy)	capacity [passengers]	Fuel liters per 100 km	PM [g/km]	CO2 [g/km]	CO [g/km]	NO [g/km]	HC [g/km]
Praha-Mladá Boleslav (Os 9504)	221	1.70	0.0027	45	0.16	0.57	0.01
Turnov - Praha (express R 1145)	467	1.07	0.0012	28	0.05	0.47	0.02
Praha - Mladá Boleslav (Os 9514)	344	1.24	0.0017	33	0.11	0.49	0.03

Overall exhaust emissions are low compared to road transport due to higher efficiency and far less transient operation of rail transport. Also, fewer people live near railroads.

Acknowledgments:

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