In-use gasoline cars retrofit with a particle filter – Israeli experience

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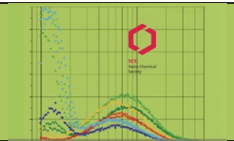

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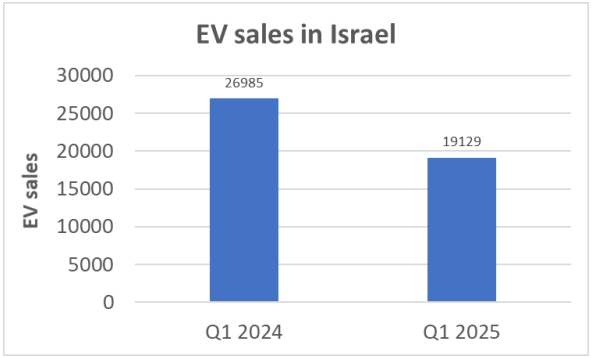
Motivation

- ✓ Particle emissions from vehicles with gasoline engines – a significant source of emissions
- ✓ High percentage of cars with a gasoline engine in Israel
- ✓ Cars that not yet equipped with a particle filter will be in use for many years
- ✓ EV boom is over – sales of EVs in Israel are dropping down
- ✓ Retrofit of particle filters is the only solution to dramatically reduce particle emissions from in-use gasoline vehicles

Background data

- Average age of road vehicles in Israel in 2024 – 7.7 year, passenger cars – 7.6 year
- 78.4% of passenger cars are gasoline-fed
- 88.9% of cars in a private ownership
- **Only 35-37% of in-use cars have OEM Gasoline Particle Filters (GPFs)**
- Drop in EV sales in the first quarter of 2025 compared to Q1 2024 by 29%
- Rise in total car sales for the same time period by 10%



Retrofitted Cars

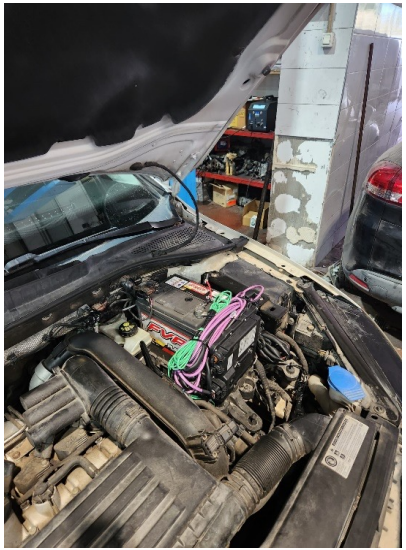
Car model	Engine model	Manufacturing year	Engine displacement, cc	Engine rated power, HP	Traveled distance on day of installation, km	Mileage travelled during the test, km	Test duration
VW Golf	CZC	2016	1395	125	118458	8540	½ year
Skoda Octavia	CZD	2016	1395	150	120986	8401	½ year

The mileage travelled by the cars during the test is slightly higher than the average distance travelled in Israel for cars of the similar age (14,800 km)

Retrofitting

HJS GPF installed

CPK data logger installed



- A certified retrofitter was selected
- Each car was inspected twice (after retrofit and after return to original configuration) by the Ministry of Transport and Road Safety (MoT)
- MoT approvals were obtained and released to the car owners

Measurement methods

- Concentrations of CO, CO_2, O_2, NO_x, particle number concentrations (PN) and noise level were measured before and after GPF installation
- Measurements – at four operating regimes:
  - ✓ Low idle (~800 rpm) with A/C switched off (no load)
  - ✓ Low idle with A/C switched on and the A/C fan in ‘max’ position (load)
  - ✓ High idle (~2,000-2,200 rpm), no load
  - ✓ High idle, load
- Instruments:
  - ✓ CO, CO_2, O_2, NO_x – Horiba PG-340 gas analyzer
  - ✓ PN concentration – AVL diTESt counter (*kindly provided by AVL for the test*)
  - ✓ Noise - Sound Level Meter model SL-4011 of Lutron

Measurement methods

- All pollutant measurement results were automatically recorded and processed off-line
- Measurement duration at each operating mode – at least 60 sec
- Noise measurement – according to the UN ECE Regulation 51
- Each car was fully warmed up before measurements starting

Results
Gaseous pollutant concentrations

Component	Low idle, no load		Low idle, load		High idle, no load		High idle, load	
	w/o GPF	With GPF	w/o GPF	With GPF	w/o GPF	With GPF	w/o GPF	With GPF
CO, ppm	29	39	60	23	9.6	~0	24	27.9
CO_2, %	15	15	15.1	15	15	15	15.1	15.1
NO_x, ppm	0.043	0.044	2.2	4	0.92	3.6	0.044	0.044
O_2, %	0.43	0.61	0.4	0.54	0.5	0.49	0.49	0.4

VW Golf,
start of the test

Component	Low idle, no load		Low idle, load		High idle, no load		High idle, load	
	w/o GPF	With GPF	w/o GPF	With GPF	w/o GPF	With GPF	w/o GPF	With GPF
CO, ppm	~0	31	10	35	~0	~0	22.5	32
CO_2, %	15.8	15.6	15.8	15.9	15.9	15.8	15.9	15.9
NO_x, ppm	0.044	10	0.044	0.93	0.044	4.5	0.044	0.044
O_2, %	~0	~0	~0	~0	~0	~0	~0	~0

Skoda Octavia,
end of the test

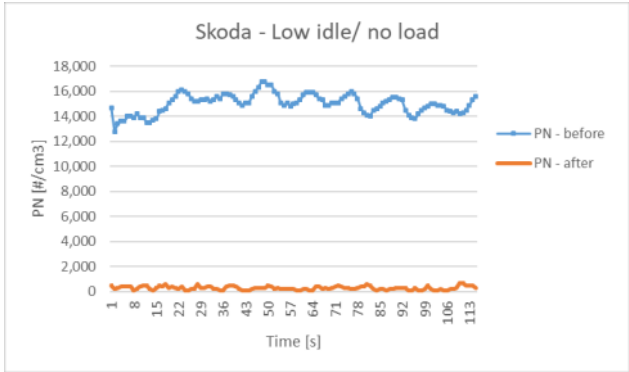
No sensible influence of GPF retrofit on operation of the car's catalytic converter was observed

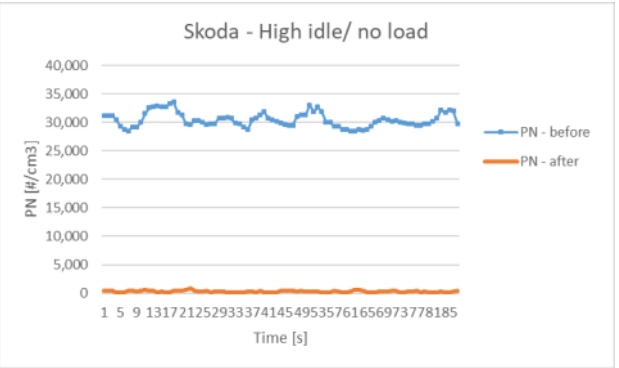
Results
Noise

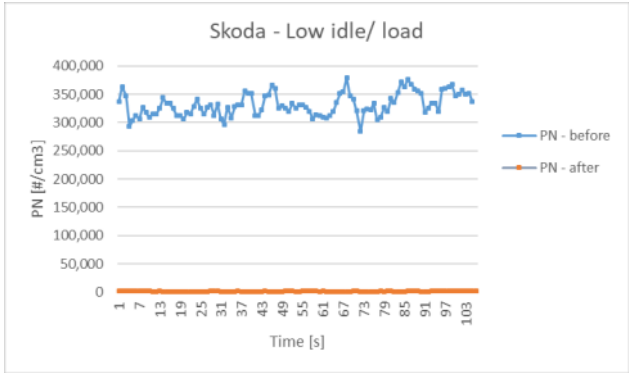
Car model	VW Golf		Skoda Octavia	
	w/o GPF	With GPF	w/o GPF	With GPF
On day of GPF installation	71	69	71	71.7
Three months after GPF installation	n/a	68.8	n/a	70.3
End of the test period – six months after GPF installation	73.3	71.1	71.2	70.3

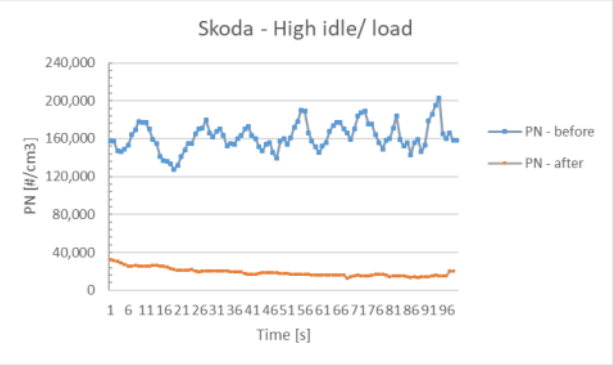
- ✓ No negative influence of GPF retrofitting on the noise level of tested cars was observed
- ✓ A tendency of noise reduction after GPF retrofit was notified

Results
PN concentrations



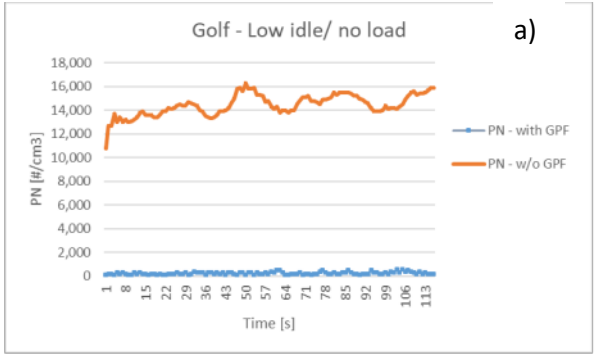


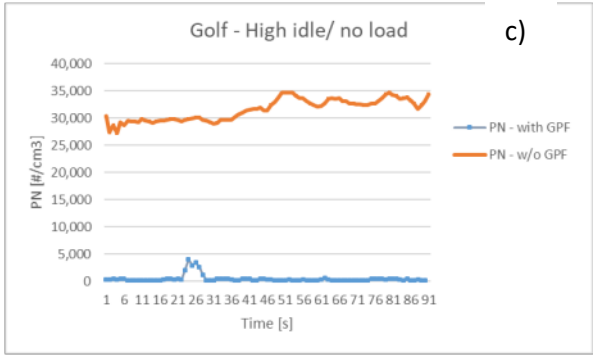


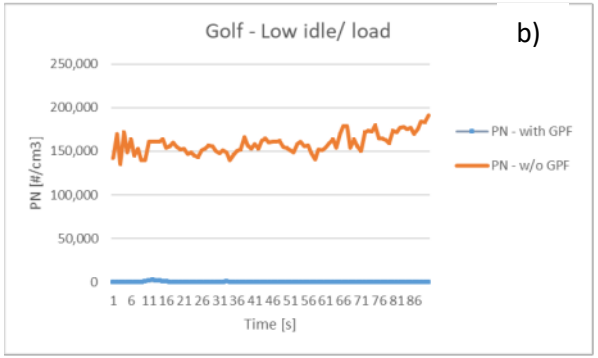


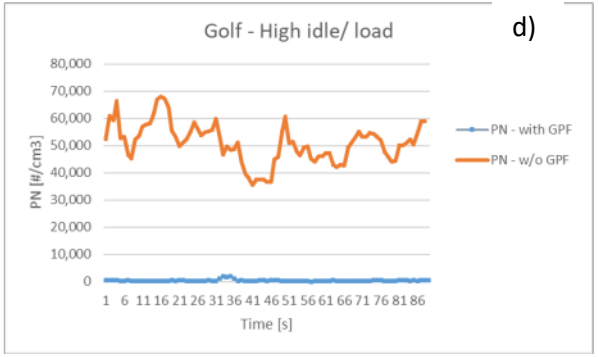
Start of the test

Results
PN concentrations









End of the test

Results
PN filtration efficiency

Date of the test	Performance parameter	Low idle - no load		Low idle - load		High idle - no load		High idle - load	
		w/o GPF	with GPF	w/o GPF	with GPF	w/o GPF	with GPF	w/o GPF	with GPF
Test start	PNC [#/cm³]	12267	306	189945	1010	27774	323	78940	2368
	PNFE, %	97.5		99.5		98.8		97	
Three months after start	PNC [#/cm³]	n/a	287	n/a	322	n/a	296	n/a	296
	PNFE*, %	97.9		99.8		99		99.5	
Test end	PNC [#/cm³]	14439	249	164633	293	31801	460	50271	332
	PNFE, %	98		99.8		98.5		99.3	

VW Golf

Date of the test	Performance parameter	Low idle - no load		Low idle - load		High idle - no load		High idle - load	
		w/o GPF	with GPF	w/o GPF	with GPF	w/o GPF	with GPF	w/o GPF	with GPF
Test start	PNC [#/cm³]	14940	286	336978	1346	30517	317	161768	27570
	PNFE, %	98.1		99.6		99.0		83.0	
Three months after start	PNC [#/cm³]	n/a	290	n/a	261	n/a	275	n/a	285
	PNFE*, %	97.2		99.9		98.7		n/a	
Test end	PNC [#/cm³]	5887	344	305295	254	13090	284	**	262
	PNFE, %	94		99.9		97.8		n/a	

Skoda Octavia

Results
PN filtration efficiency – important remarks

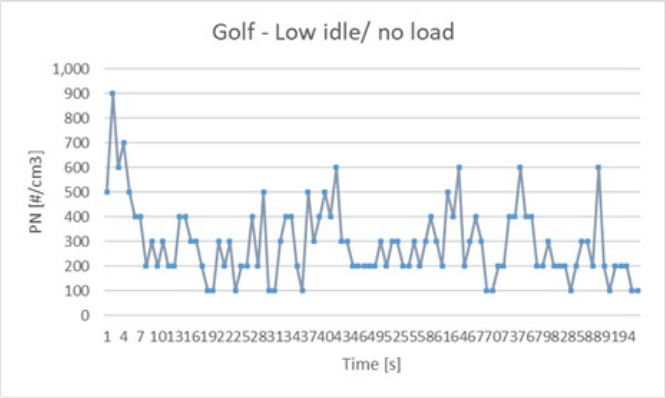
- Both tested cars demonstrated stable PN emission behavior during the test period
- In absolute majority of tests GPF demonstrated a very high effectiveness in PN emissions mitigation
- The calculated values of PNFE for both cars at four tested regimes during the test usually were higher than 97%
- PN emission at low idle operation without GPF is very sensitive to the engine load (switching-on the air conditioner) – PNC rise to 3.37E+5 #/cm^3
- Car retrofitting with a GPF significantly mitigated the mentioned sensitivity to load

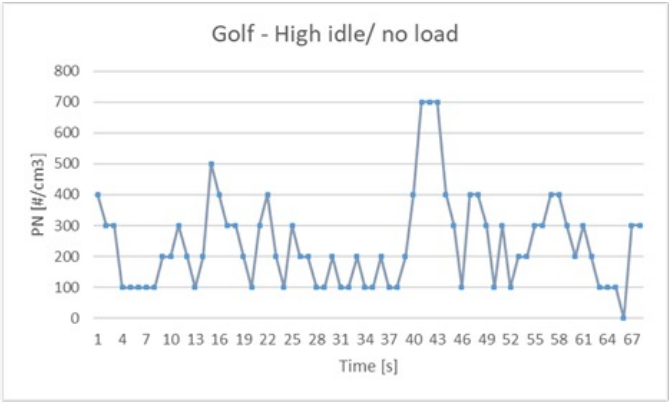
Results
Comparison with an OEM-installed GPF

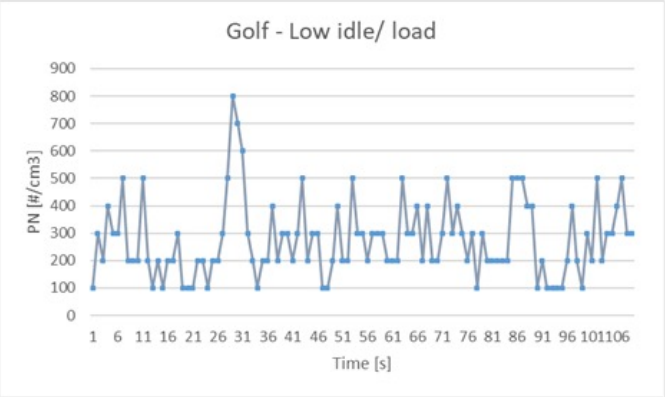
Tested car with an OEM-installed GPF

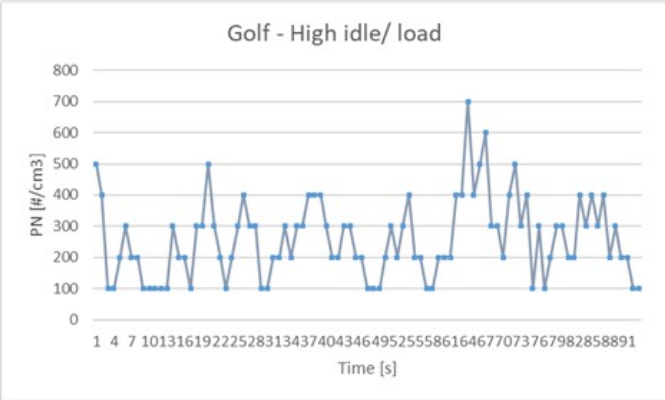
Car model	Engine model	Manufacturing year	Engine displacement, cc	Engine rated power, HP	Traveled distance on the day of measurement, km
VW Golf	DFY	2022	1498	150	51208

Results
Comparison with an OEM-installed GPF

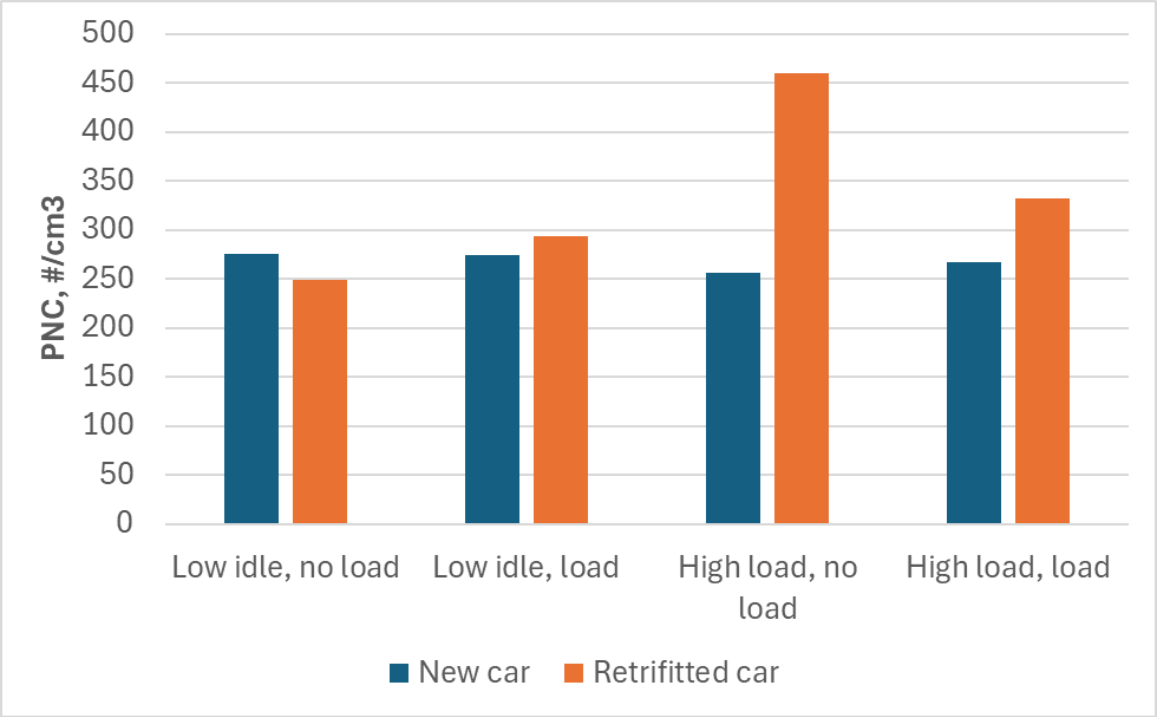








Results
Comparison with an OEM-installed GPF



The car with a retrofitted filter emits similar amounts of particle matter at all tested regimes

Summary

- No sensible influence of GPF installation on operation of the car's catalytic converter and its effectiveness
- No negative influence of GPF retrofitting on the noise level of tested cars
- The retrofitted GPF demonstrated similar gaseous pollutant concentrations and noise level as compared to the OEM-installed filter
- Both tested cars demonstrated quite stable PN emission behavior during the test period
- GPF demonstrated a very high effectiveness in PN emissions mitigation - >97%
- Cars with a retrofitted GPF emits similar amounts of PN as an OEM-installed GPF
- No indications on the backpressure rise during the six-month's test

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Q & A

Thank you for your attention!

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