

TNO report

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Diesel Particle Filters

Anna van Buerenplein 1
2595 DA Den Haag
P.O. Box 96800
2509 JE The Hague
The Netherlands

www.tno.nl

T +31 88 866 00 00

Date	13 December 2018
Author(s)	Ing. Jan Staps (WEL company) Dr. Norbert E. Ligterink
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Samenvatting

Achtergrond

Verontreinigende deeltjesemissies van dieselmotoren zijn schadelijk voor de gezondheid. De introductie van het roetfilter heeft ervoor gezorgd dat moderne dieselauto's nauwelijks nog een rol spelen in dit luchtkwaliteitsprobleem. Maar er zijn indicaties dat roetfilters onderhoudsproblemen geven en daarom verwijderd worden. De omvang van dit probleem, en het effect op de emissies van fijnstof en elementair koolstof is onbekend. Dit onderzoek geeft een eerste inzicht in de aard en omvang van het verwijderen van roetfilters. Het onderzoek is uitgevoerd in opdracht van het RIVM, in het kader van de Nederlandse Emissieregistratie. Het onderzoek is grotendeels uitgevoerd door WEL company, met ondersteuning van TNO.

De verbranding van brandstof in de dieselmotor van auto's veroorzaakt o.a. uitstoot van roetdeeltjes. Deze roetdeeltjes komen via de uitlaat in de atmosfeer terecht. Sinds 2007 is door fabrikanten, gestimuleerd door de Nederlandse overheid, begonnen met het uitrusten van nieuwe dieselauto's met een gesloten roetfilter (DPF) om de uitstoot van roetdeeltjes te verminderen. Sinds de introductie van de Euro 5 emissie grenswaarden in 2009 was het niet meer mogelijk zonder een DPF te voldoen en zijn alle nieuwe dieselauto's uitgerust met een roetfilter.

Er zijn aanwijzingen dat roetfilters opzettelijk worden verwijderd, doorgeboord, of intern leeggehaald om de kosten van reiniging of vervanging te vermijden. Het verwijderen of leeghalen van roetfilters wordt vaak gecombineerd met een aanpassing van de motorregeling, in het bijzonder de OBD-software; dit om o.a. de detectie van een defect roetfilter tijdens APK-inspecties te voorkomen.

Doelstellingen en aanpak

De doelstellingen van het gepresenteerde onderzoek zijn:

1. Bepaling van het percentage auto's dat een verwijderd of leeggehaald roetfilter heeft. Op basis van dit percentage kan de impact op de luchtkwaliteit nauwkeuriger worden berekend.
2. Subdoel, inzicht in de markt, aanbieders en prijzen van de verwijdering van roetfilters. Om de aard van het probleem beter in kaart te brengen.

Het onderzoek is opgedeeld in twee verschillende benaderingen:

- **Interviews:**
Landelijk onderzoek door middel van interviews bij autogarages die het onderhoud van dieselauto's verzorgen.
- **Desk research:**
Met een vooraf gedefinieerd script de bereidheid, prijzen en mogelijkheden te onderzoeken bij autogarages en 'tuning stations'.

Resultaten - Interviews

Binnen het onderzoek zijn 89 autogarages benaderd in Nederland, 83 autogarages (93,3%) werkten mee aan het onderzoek.

Zes autogarages (6,7%) waren niet bereid om mee te werken aan het onderzoek. Op de onderzoeker kwam het over alsof deze autogarages zich bedreigd voelden door het onderzoek.

In het interview gaven 32 autogarages (38,6%) aan dat ze klanten met dieselauto's kennen waarbij het roetfilter is verwijderd. Tezamen kennen ze 212 klanten met een verwijderd roetfilter, gemiddeld 2,5 klant per autogarage.

Binnen het onderzoek zijn 86 autogarages benaderd, welke in totaal 27.650 diesel voertuigen jaarlijks onderhouden. Dit aantal is 1,05% van het totaal rijdend wagenpark in Nederland. Op basis hiervan wordt ingeschat dat het roetfilter verwijderd is bij 1,2% van alle diesel personenauto's en lichte bedrijfswagens. In het totaal rijdend wagenpark in Nederland komt dit neer op 20.284 verwijderde roetfilters.

De hoge kosten van vervanging van het kapotte filter (gemiddeld EUR 1.200,-) of het reinigen van filters is de voornaamste reden van klanten om het roetfilter te laten verwijderen.

Resultaten – Deskresearch

Binnen het deskresearch zijn er 46 bedrijven benaderd met het vooraf gedefinieerd script. Al deze bedrijven boden via hun website de service aan voor het verwijderen of aanpassen van het roetfilter. In totaal gaven 25 bedrijven een reactie, waarvan vier bedrijven eerst diagnose willen stellen voordat ze een advies wilden geven.

Van deze reacties zijn er 15 bedrijven bereid om roetfilter te verwijderen en de OBD-software aan te passen van het voertuig. De andere zes bedrijven waren niet bereid om het roetfilter te verwijderen op basis van wetgeving en APK-controles. In totaal was 32,6% van de bedrijven bereid het roetfilter te verwijderen.

Conclusies en aanbevelingen

Op basis van het uitgevoerde onderzoek is ingeschat dat bij 1,2% van alle diesel personenauto en lichte bedrijfswagens met roetfilter het roetfilter verwijderd. Dit aandeel vertegenwoordigt 20.284 auto's met een verwijderd roetfilter. Het verwijderen van het roetfilter heeft een enorme impact op de uitstoot van roetdeeltjes. In de stad hebben auto's met een verwijderd roetfilter een 150 keer grotere uitstoot van fijnstof dan auto's met een werkend roetfilter. Het aandeel van 1,2% wordt als het minimum beschouwd.

Naar verwachting zal dit aandeel in werkelijkheid groter zijn, gebaseerd op de onderstaande verschillende redenen:

- 6,75% van de autogarages was niet bereid om mee te werken aan het onderzoek. Om toch een indruk te krijgen van de mogelijke impact is een aanname gemaakt dat de garages hetzelfde aantal roetfilters hebben verwijderd als de universele garage met de hoogste score. Dit zou resulteren in een aandeel verwijderde filters van 1,6% (in plaats van 1,2%).
- Niet alle garages zijn op de hoogte van de aanpassingen aan het roetfilter van een voertuig. Simpelweg omdat de klant dit rechtstreeks met een tuning bedrijf kan regelen buiten de autogarage om.

De hoeveelheid tuning bedrijven en het gemak om hier een afspraak te maken voor verwijdering versterken deze gedachtegang. Autogarages verliezen ook regelmatig klanten uit het oog nadat deze een 'hoge' offerte hebben ontvangen voor het vervangen van een filter.

- Het brede scala aan tuning bedrijven welke wekelijks roetfilters verwijdert ten tijde van het uitvoeren van dit onderzoek. Het aantal actieve bedrijven, dat roetfilters verwijdert, kan gemakkelijk het aantal verwijderde roetfilters verklaren.

Het is de verwachting dat zonder handhaving van het verbod op het verwijderen van roetfilters het probleem verder kan toenemen, omdat voertuigen met roetfilters nu jonger zijn dan elf jaar, en met toenemende leeftijd meer problemen zullen geven. Daarmee neemt het risico toe dat roetfilters worden verwijderd in plaats van worden vervangen.

Deskresearch heeft aangetoond dat de service van het verwijderen van een roetfilter gemakkelijk en toegankelijk is voor klanten in elke provincie of stad. Ondanks dat het wettelijk verboden is blijkt uit dit onderzoek dat bedrijven nog steeds deze service aanbieden.

Aanvullend onderzoek richting universele garages en tuning stations welke het verwijderen van het filter aanbieden wordt aanbevolen omdat een aantal bedrijven niet gereageerd heeft op ons bezoek of e-mail. In de ideale situatie wordt dit onderzoek uitgevoerd met een praktijkvoertuig voorzien van een defect roetfilter. Op basis van dit onderzoek is een eerste inschatting gemaakt van het aantal voertuigen met verwijderde roetfilters. Om dit beeld verder te bevestigen en/of verfijnen wordt geadviseerd om grotere steekproeven uit te voeren aan willekeurige voertuigen langs de weg. Deze auto's moeten willekeurig gekozen worden omdat eigenaren van een voertuig met verwijderd roetfilter zich mogelijk niet vrijwillig zullen aanmelden voor een test.

Summary

Background

With the introduction of the Diesel Particulate Filter (DPF), the particulate matter (PM) emissions of diesel cars has decimated, and, therefore, modern diesel cars play a minor role in PM air-quality problems. However, there are concerns that filters are removed from diesel cars, e.g., to avoid maintenance problems, which has a detrimental effect on particulate matter emissions. This study investigates the nature and magnitude of the problem of DPF removal. The research was carried out for the RIVM as part of the Dutch Pollutant Release and Transfer Register project. The research is carried out by WEL company with the support of TNO on emission specific details.

The combustion of diesel in the engine of a car causes the formation of soot particles. These soot particles are emitted in the atmosphere via the exhaust. Since 2007 diesel cars are equipped with a Diesel Particulate Filter to reduce the emission of soot particles, as part of the Dutch subsidy program. Since the introduction of the Euro 5 emission limits in 2009 all new diesel cars are equipped with a Diesel Particulate Filter.

There are indications that DPFs are removed or deliberately destroyed internally to avoid the cost of cleaning. The removal or destruction of DPFs is often combined with adaption of the OBD software to avoid detection during technical inspections.

Objectives and approach

The objectives of the presented research are:

1. Determine which percentage of vehicles has a damaged or removed DPF, based on this percentage the impact regarding air quality can be further calculated.
2. Supporting goal, insight in market, pricing and providers of DPF removals to get a better understanding of the motives and easiness for vehicle owners.

The research is divided into two separate parts:

- **Interviews:**
Investigate by interviews car workshops nationwide which provide the maintenance of diesel vehicles.
- **Desk research:**
Investigate (with a predefined script) the willingness, pricing and options at car workshops.

Results - Interviews

In total 89 car workshops are visited in the Netherlands, 83 workshops (93.3%) were cooperative with the research. However, six workshops (6.7%) were not willing to cooperate. According to the researcher these companies acted strange and they seemed threatened by the research.

In the interview, 32 workshops (38.6%) indicated that they know customers who have removed the DPF. Together they know 212 customers with a removed DPF, an average of 2.5 customers per workshop.

Within the research 86 workshops are approached, which represent the maintenance of 27.650 diesel vehicles yearly. This represents 1.05% of the total Dutch market of diesel vehicles. Within this diesel passenger and light commercial vehicles in 1.2% the DPF filter is removed. This share represents a total 20,284 vehicles with a removed DPF in the full market.

High costs on the filter replacement (an average of € 1200) or filter cleaning motivates most costumers to remove the DPF.

Results – Desk research

In the desk research 46 workshops are approached that actively offer the removal of DPF on their website with a predetermined script. In total were 25 workshops willingly to answers to the questions, four workshops first requested to check the car before they give an advice.

From the active responses 15 workshops were willing to remove DPF and adapt the OBD software on the vehicle. The other 6 workshops were not willing to remove the DPF based on legal violation and new visual control at technical inspection, they only perform the removal on vehicles older than 2011. Based on the total number of approached workshops 32.6% is willing to remove the DPF even though this is forbidden by law.

Conclusions and recommendations

Overall in 1.2% of all diesel passenger and light commercial vehicles with DPF this filter is removed. This share represents a total 20,284 vehicles with a removed DPF in total Dutch fleet. The impact on particle matter emissions on these vehicles is huge, within city-use these vehicles have a 150 times larger emission than usual emission with a functioning DPF.

The share of 1.2% is considered the minimum, this share is expected to be higher in reality based on the several reasons:

- 6.75% of the vehicle workshops were not willing to cooperate with the research. Their unwillingness suggests that they have something to hide. The impact of the workshops is calculated, in the calculation is assumed that they have the same number of removals of DPF than the highest cooperative workshop. This results in an overall share of 1.6% (instead of 1.2%).
- Not all vehicle workshops are aware of the changes to the DPF of vehicle. Simply because this is arranged directly between the tuning stations and customer. The wide range of tuning stations and ease to make an appointment reinforces this train of thought.
- The wide ranges of tuning stations with multiple years of experience and weekly removal of DPFs, outside the scope of the workshops that perform the regular maintenance. The number of workshops can easily cover the 1.2% removal.

It is expected that the problem with DPF removal will increase over time. Vehicles with DPF are still relatively young, at elf years of less. With increasing age, the problems may increase as well, as the removal rate.

The desk research has shown that the service of removing the DPF is easily accessible for customers in every province or city. Even if it is forbidden by law, these workshops still offer this service.

It is recommended to further investigate universal workshops and tuning stations that provide the service of the removal. Because some workshops do not respond to digital contact this further investigation should ideally be with a prepared vehicle with a defect DPF. To further refine the number of removed DPFs on the road it is recommend performing a road test with random physical vehicles. You need random vehicles because people who have knowingly removed the filter will never sign up for a road test. This test validates the data of 1.2% removals from the interviews.

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1 Introduction

The Dutch Pollutant Release and Transfer Register (PRTR) reports on pollutant emissions in the Netherlands. Both particulate matter (PM) and Elemental Carbon (EC) emissions are included in the public inventory. With the recent concerns of removal of particulate filters from diesel vehicles, and the resulting increase in emissions, the PRTR project of the RIVM has requested an assessment of the nature, the magnitude and the impact of the problem of diesel particulate filter removal in the Netherlands. This report is the result of the investigation of WEL company, who performed the study, with the help of TNO, to place its results in the perspective of national emissions levels of the current vehicle fleet.

1.1 Background

The combustion of diesel in the engine of a car causes the formation of soot particles. These soot particles are emitted in the atmosphere via the exhaust. Since 2007 newly sold diesel cars are equipped with a Diesel Particulate Filter (abbr. DPF) to reduce the emission of soot particles. Since the introduction of the Euro 5a emission limits in 2009 all new diesel cars are equipped with a Diesel Particulate Filter to meet the particulate mass emission of 5 mg/km. Since Euro 5b a particulate number emission limit ensures a DPF is needed to meet this limit, also in the future. Prior to Euro 5a, DPF technology was stimulated and present in Euro 4 diesel passenger cars in increasing numbers from 2005.



Figure 1: Diesel Particle Filter of a passenger vehicle, as part of the exhaust system.
The filter element (see Figure 2) is in the metal housing (photo: Topcats)



Figure 2: A built-out (closed) ceramic filter element, used in a Citroen C4. This particle filter has a diameter of about 10 cm and is about 20 cm high (photo: TNO at Digicar Engineering).

There are indications that DPFs are removed or deliberately destroyed internally to avoid the cost of cleaning or replacement. The removal or destruction of DPFs is often combined with adaption of the OBD (On Board Diagnostics) software to avoid detection during inspections.

The TNO report R10307v2 from 2015 has concluded that 6% of the tested vehicles (21 of 355) either had damaged or removed Diesel Particle Filters on the basis of elevated particulate number emissions in stationary tests. In case of damage the emissions will be elevated, but not to the same levels as for a removed filter. From emission testing this distinction is difficult to make. Based on this indication the Dutch market is further investigated on the removal or destruction of DPF's.



Figure 3: Internally adjusted Diesel Particle Filter (photo: OBD-Chiptuning).

The particle matter emission has been limited to 5 mg/km by the introduction of European emission standard Euro 5a. This limit could only be achieved with a DPF, without a DPF the vehicles will not meet the current requirements within the Euro 5b and Euro 6 emission standard, which includes a particulate number limit of 6.0×10^{11} #/km, and a reduction of the particulate mass limit to 4.5 mg/km.

It is prohibited by Dutch law to remove DPF filters from vehicles which are definitely Euro 5 on the basis of the registration date:

- Light Commercial Diesel vehicles of 2012 and younger.
- Passenger Diesel vehicles of 2011 and younger.

Light Commercial Vehicles (EC category N1), also referred to as LCV's or vans, are light commercial vehicles with a gross vehicle weight (GVW) under 3,500 kg.

1.2 Figures 'DPF in Dutch market'

The amount of DPFs in the Dutch market is growing annually since all new cars comply to the current Euro emission standards. In 2013, 50% of light duty diesel vehicles was equipped with a DPF, the percentage rose to 62.8% in 2017. An average growth of 3.2% per year, resulting from the renewal rate of diesel vehicles in the total fleet.

Table 1: Division between diesel vehicles of the 2017 Dutch Light Duty fleet with and without and DPF (source: RDW OpenData 27-11-2017).

Type of vehicle	With DPF		Without DPF		Total
	Amount	Share	Amount	Share	Amount
Diesel passenger vehicles	1,192,220	72,2%	458,911	27,8%	1,651,131
Diesel light commercial vehicles	468,937	47,2%	525,440	52,8%	994,377
Diesel passenger and light commercial vehicles	1,661,157	62,8%	984,351	37,2%	2,645,508

The average particle matter emission from a diesel vehicle without a DPF is about 30 mg/km. With a DPF installed the particle matter emission is 0,2 mg/km (150 times less) within cities and 2 mg/km (15 times less) on the highway. For elemental carbon (EC) the increase in emissions is even bigger: the EC fraction in particulate matter in the case of a DPF is 10%, while without DPF the EC fraction is close to 100%.

The emission on the highway of a vehicle with DPF is higher because the regeneration process of the filter, which usually occurs during highway driving, is associated with additional particulate matter emissions.

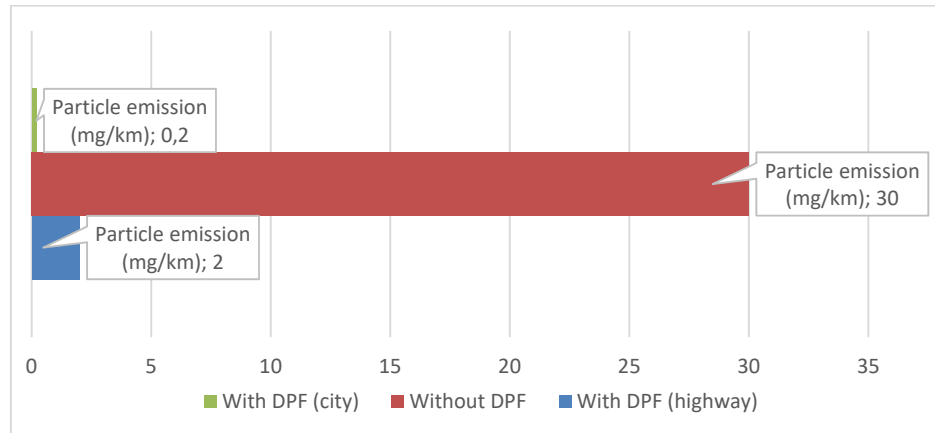


Figure 4: Particle emission difference between vehicles with or without vehicles.

1.3 Objectives and approach

The objectives of the presented research are to:

1. Main objective. Determine which percentage of vehicles has a damaged or removed DPF. Based on this percentage the impact regarding air quality can be calculated more accurately.
2. Supporting goal, if many DPF are removed gain insight in market, pricing and providers of DPF removals to get a better understanding of the motives and easiness for vehicle owners.

The research is divided into two separate approaches:

- **Interviews:**
Investigation by interviewing car workshops nationwide which provide the maintenance of diesel vehicles.
- **Desk and field research:**
Investigate (with a predefined script) the willingness, pricing and options for DPF removal at car workshops.

2 Research activities

The research into the DPF removal is divided into two separate approaches. The first approach is interviews on location. Interviews were held with car workshops nationwide which are focused on the maintenance of diesel vehicles.

The second approach is a desk research, in this approach there are virtual customers created with problems with the DPF.

2.1 Interviews

In the interview approach car workshops (“garages”) are interviewed because they have direct contact with the car-owner and/or driver. The car workshops are categorized in two groups, brand or dealer workshop and universal workshop. In total 98 workshops in 11 of 12 available provinces were interviewed. The workshops are selected based on the top 10 diesel brands within the Dutch driving fleet.

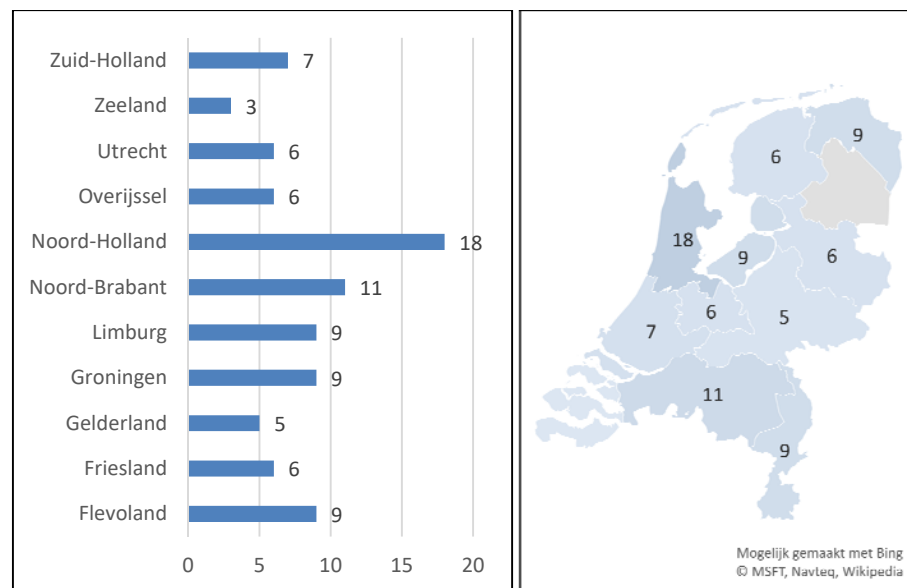


Figure 5: Amount of visited car workshops in the Netherlands per province

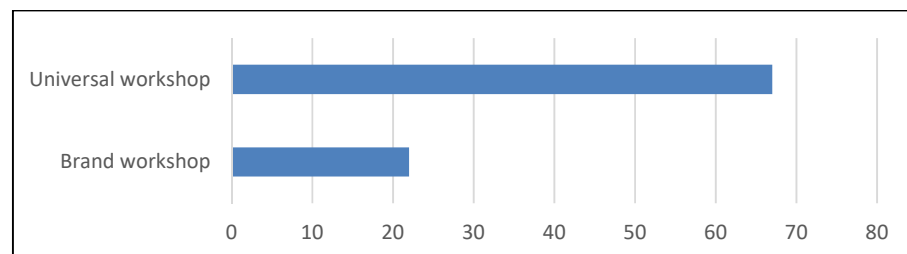


Figure 6: Amount of visited car workshops divided into groups

The following topics were discussed within the interviews:

- New regulations as of May 20th 2018 regarding a visual check on DPF within technical inspection (the roadworthiness tests, PTI, in Dutch: “APK”).
- The number of technical inspections executed annually on diesel vehicles.
- The number of diesel vehicles with removed or adjusted the DPF divided in private and business use.
- The reason for removing or adjusting the DPF.

2.2 Desk research

In the desk research 46 workshops are selected through Google, these workshops actively offer the removal of a DPF based on the information provided on their website. And were approached within the research with a predetermined script based on the virtual cases.

In this script a customer pretended to have a diesel passenger car with a failure in the DPF. The vehicle had gone to the brand workshop, but the price of the replacement was too high. The customer wanted to know if there are other methods to solve the problem at a hypothetical smaller price than replacement of the original DPF. The customer also wanted to know how much experience the workshop has in this alternative method.

The script brought the following information:

- How many workshops are actually willing to remove the DPF after e-mail contact.
- What is the average price of the removal of a DPF.
- How much experience do these workshops have in the removal of DPF and how many DPFs do they remove monthly.

3 Results

3.1 Interviews in the workshops

In total 89 car workshops were visited in the Netherlands, 83 workshops (93.3%) were cooperative with the research. However, 6 workshops (6.7%) were not willing to cooperate. According to the researcher these companies acted peculiar and they seemed threatened by the research.

From the 83 workshops that were cooperative with the research the results are stated below. The interviews were conducted in July and August 2018.

The car workshops represent the maintenance in total of 27,650 light duty diesel vehicles, 7,157 vehicles are maintained at brand workshops and 20,493 at universal workshops.

Table 2: Number of diesel Vehicles maintained by invested workshops.

<i>Type of workshop</i>	<i>Number of diesel vehicles maintained</i>
Brand workshops	20,493
Universal workshops	7,157
<i>Total</i>	<i>27,650 (1,05% share of total diesel Dutch Fleet)</i>

All the workshops were up to date with the new Dutch regulations as per May 20th, 2018 regarding a visual control on DPF at periodic technical inspections.

In the interview, 32 workshops (38.6%) indicated that they know vehicles who have removed the DPF. Together, they know 212 diesel vehicles with a removed DPF, an average of 2.5 vehicles per workshop. The highest score at one workshop was 30 vehicles. In all these cases the DPF was deliberately destroyed internally (i.e., the porous ceramic material) to avoid the clogging up of the filter. To prevent disruptions, and MIL (Malfunction Indicator Light) in the system the OBD software was modified. These adjustments of DPF were performed by specialized DPF removal workshops.

Table 3: Number of known DPF removals within invested workshops.

<i>Type of workshop</i>	<i>Number of known DPF removed vehicles</i>	<i>Number of workshops with customers with removed DPF</i>
Brand workshops	5	4
Universal workshops	212	28

In the interview, 172 private customers (81%) and 40 business customers (19%) had removed the DPF from their vehicle.

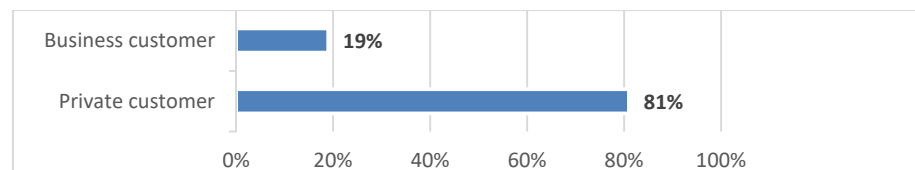


Figure 7: Removal of DPF divided by type of customers.

Table 4: DPF removal share within interviews.

<i>Type of workshop</i>	<i>Respective number of diesel vehicles maintained with DPF</i>	<i>Number of known DPF removed vehicles</i>	<i>Share of removed DPF</i>
Brand workshops	4,495	5	0.1%
Universal workshops	12,870	207	1.6%
Total	17,365	212	1.2%

The DPF is removed at 1,2% of all diesel passenger and light commercial vehicles.

Table 5: Exploratory DPF removal relative to the entire market.

<i>Type of vehicle</i>	<i>Research</i>		<i>100% of market</i>	
	<i>Number</i>	<i>Share</i>	<i>Number</i>	<i>Share</i>
Diesel passenger and light commercial vehicles without DPF	212	1,05%	20,284	100,0%

Within the research 86 workshops are approached, which represent the maintenance of 27.650 diesel vehicles yearly. This represents 1.05% of the total Dutch market of diesel vehicles. Within this diesel passenger and light commercial vehicles in 1.2% the DPF filter is removed. This share represents a total 20,284 vehicles with a removed DPF in the full market.

These new PM values is relatively provided 3,042,600 vehicles with DPF versus 20,284 vehicles without DPF in city use. Given the fact that all LCVs cover 17 billion kilometres annually, and all diesel passenger cars 35 billion kilometres, the urban PM emissions of vehicles with a filter will be around 3.6 ton, the 1.2% removal of filters will increase the particulate matter emissions to about 6 ton. This is an increase of 70%. For EC emissions the increase is threefold higher, because filters are more efficient in filtering EC than PM emissions. In the future a further increase is to be expected, but with the decreasing PM emissions of other sources, the relative effect will increase more.

Table 6: Identified reasons for DPF removal based on interviews.

<i>Reason</i>	<i>Number</i>	<i>Share</i>
High maintenance costs on filter cleaning or replacement	124	58,5%
Permanent solution, no chance of recurring problems	44	20,8%
Recurring problems with DPF	44	20,8%
Performance	0	0,0%
Total	212	100,0%

The main reason for removal of DPF is the high maintenance costs on filter cleaning or replacement (58,5%)

In a synopsis of all the interviews it is clear that the reason of removing the filter is based on activated malfunction indication lights and problems like a clogged or damaged DPF. These problems arise from mainly two causes. The first cause is by driving short distances, and low velocities, with a diesel vehicle. Therefore, the DPF cannot regenerate properly and gets blocked. This can happen to diesel vehicles of all ages. The second cause is wear of the ceramic.

The lifespan of the DPF is between 160.000 and 240.000 kilometers and this mileage generally achieved by vehicles of 7 years or older. After this mileage the DPF is worn out, gives failure signals and need to be replaced.

In both areas the price of the replacement or cleaning triggers towards the removal of the DPF. The majority of the customers perform this removal directly at the first-time filter problems occur.

3.2 Remote interviews, email contact, and internet search

In the desk research 46 workshops that actively offer the removal of DPFs on their website were approached with a predetermined script. In total 25 workshops were willingly to answer the questions, 4 workshops first requested to check the car before they gave an advice. Because there is no actual vehicle to check the communication ended at that point. For the workshops that gave no response the communication is ended at that point. The desk research is performed in July 2018.

Table 7: Response of approached workshops.

Response	Number	Share
No response	21	45.7%
Active response – requested to check the car first	4	8.7%
Active response - Willing to remove DPF and adapt the OBD software	15	32.6%
Active response - Not willing to remove DPF based on law regulations	6	13.0%
Total	46	100,0%

From the active responses 15 workshops were willing to remove DPF and adapt the OBD software on the vehicle. The other 6 workshops were not willing to remove the DPF based on legal violation and new visual control at technical inspection, they only perform the removal on vehicles older than 2011. Based on the total number of approached workshops 32.6% is willing to remove the DPF even though this is forbidden by law.

The average price of the removal of DPF and adapting the OBD software was EUR 409 incl. VAT. The lowest price was EUR 300 incl. VAT and the highest was EUR 650 incl. VAT.

The 15 workshops that were willing to remove the DPF said they have multiple years of experience in DPF removal. Most of them perform the activity on a weekly basis, two big workshops even daily.

4 Conclusions and recommendations

The increase of DPF's in the car market, and the increasing age of vehicles with DPF, increases the risk of removing a DPF due to the high costs of replacement or cleaning. At the time this research was conducted there were several workshops that perform this service. Especially tuning stations this service seems easily added to their activities, since they already have the equipment to prevent activation of the malfunction indication light with a DPF malfunction.

Based on the current periodic technical inspection "APK" the demand for the removal of DPF is expected to increase.

This has several reasons:

- Small chance of being caught, not measurable within current technical inspection.
- The price for the replacement of the DPF is high (EUR 1.200,-), this is relatively expensive versus the removal of DPF (EUR 409,-).
- In the next years more and more vehicles are eligible for a replacement of DPF. A DPF must be pre-emptively replaced at a mileage between 160,000 and 240,000 kilometers depending on the instructions of manufacturers.

The introduction of the visual DPF inspection at the periodic technical inspection has a positive effect on the reduction of DPF removals. Although the chance of being caught is low, the introduction of the visual test should trigger workshops to stop with this service. Within the research 28.8% of the workshops do not offer this service based on the legal violation and new visual control at technical inspection.

Brand workshops have a low share of 0.1% of vehicles they know of having a removed DPF. The pith of the matter is in the universal workshops with a 1.6% share of removed DPFs. These workshops maintain older vehicles with higher mileages and more DPF problems.

Within the research 86 workshops are approached, which represent the maintenance of 27.650 diesel vehicles yearly. This represents 1.05% of the total Dutch market of diesel vehicles. Within this diesel passenger and light commercial vehicles in 1.2% the DPF filter is removed. This share represents a total 20,284 vehicles with a removed DPF in the full market. The impact on particle matter emissions on these vehicles is huge, within city-use these vehicles have a 150 times larger emission than usual.

The share of 1.2% is considered the minimum, this share is expected to be higher in reality based on the several reasons:

- 6.75% of the vehicle workshops were not willing to cooperate with the research. Their unwillingness may suggest that they have something to hide. The impact of the workshops is calculated, in the calculation is assumed that they have the same number of removals of DPF as the highest cooperative workshop. This results in an overall DPF removal share of 1.6% (instead of 1.2%).

- Not all vehicle workshops are aware of DPF removals. Simply because this is arranged directly between the tuning stations and customer. The wide range of tuning stations and ease to make an appointment reinforces this conjecture.
- The wide ranges of tuning stations with multiple years of experience and weekly removal of DPFs.

There is one reason why the share may decrease. The problems observed with DPFs now are from the first generation of filters after introduction. The technology may have improved in the meantime, resulting in less malfunctions after prolonged use. Manufacturers may have taken the problems with DPFs on board to develop more robust technology.

The desk research has shown that the service of removing the DPF is easily accessible for customers in every region or city. Even if it is forbidden by law, these workshops still offer this filter removal service publicly.

It is recommended to further investigate universal workshops and tuning stations that provide the service of the removal. Because some workshops did not respond to digital contact this further investigation should ideally be with a prepared vehicle with a defect DPF.

To further refine the number of removed DPFs on the road it is recommend performing a road test with random vehicles. You need random vehicles because people who have knowingly removed the filter will never sign up for a road test. This test validates the data of 1.2% removals from the interviews.

For air-quality, even a small fraction of 1.5% removal of DPF has significant impact on the emissions of diesel cars, particularly in urban areas. The urban PM and EC emission factors have to be increased by 100% and 300% respectively. For motorways an increase of 26% is expected for PM. Moreover, since diesel cars with DPFs are now reaching the age of 10 years, it is expected that the fraction of diesel cars with DPF removed will grow in the years to come. Currently, there are almost a million older diesel cars and vans without an original DPF. These vehicles will be replaced with vehicles with a DPF in the future, increasing the group of vehicles with a risk of DPF removal. Once removed, the vehicle will continue to drive without DPF, leading to a further increase. Very likely, the current estimate of 1.5% of removed filters on all vehicles with a filter is low initial, signaling only the start of a problem, if not stemmed.

5 Attachments

5.1 Interview research data

Nr.	City	Province	Type of workshop	Cooperation interview	Amount of diesel vehicles maintained yearly	Known number of vehicles with removed DPF
1	Almere	Flevoland	Brand workshop	Yes	800	0
2	Almere	Flevoland	Universal workshop	Yes	400	0
3	Almere	Flevoland	Universal workshop	Yes	100	0
4	Almere	Flevoland	Universal workshop	Yes	416	0
5	Almere	Flevoland	Universal workshop	Yes	260	0
6	Almere	Flevoland	Universal workshop	Yes	208	3
7	Almere	Flevoland	Universal workshop	Yes	150	6
8	Almere	Flevoland	Universal workshop	Yes	260	13
9	Almere	Flevoland	Universal workshop	No		
10	Drachten	Friesland	Brand workshop	Yes	650	0
11	Drachten	Friesland	Universal workshop	Yes	700	0
12	Drachten	Friesland	Universal workshop	Yes	150	0
13	Drachten	Friesland	Universal workshop	Yes	1500	6
14	Heerenveen	Friesland	Universal workshop	Yes	1250	4
15	Heerenveen	Friesland	Universal workshop	Yes	400	20
16	Doetinchem	Gelderland	Universal workshop	Yes	15	0
17	Doetinchem	Gelderland	Universal workshop	Yes	400	0
18	Doetinchem	Gelderland	Universal workshop	Yes	720	0
19	Doetinchem	Gelderland	Universal workshop	Yes	260	0
20	Doetinchem	Gelderland	Universal workshop	Yes	500	30
21	Groningen	Groningen	Brand workshop	Yes	300	0
22	Groningen	Groningen	Brand workshop	Yes	10	0
23	Groningen	Groningen	Brand workshop	Yes	125	0
24	Groningen	Groningen	Brand workshop	Yes	700	1
25	Groningen	Groningen	Brand workshop	Yes	1500	10
26	Groningen	Groningen	Universal workshop	Yes	300	0
27	Groningen	Groningen	Universal workshop	Yes	60	0
28	Groningen	Groningen	Universal workshop	Yes	300	10
29	Zuidwolde	Groningen	Universal workshop	Yes	250	0
30	Hunsel	Limburg	Universal workshop	Yes	312	3
31	Kelpen-Oler	Limburg	Universal workshop	Yes	208	0
32	Nederweert	Limburg	Universal workshop	Yes	78	0
33	Nederweert	Limburg	Universal workshop	Yes	156	3
34	Posterholt	Limburg	Universal workshop	Yes	25	1
35	Swalmen	Limburg	Universal workshop	Yes	416	25
36	Weert	Limburg	Universal workshop	Yes	156	7
37	Weert	Limburg	Universal workshop	Yes	1040	9
38	Ittervoort	Limburg	Universal workshop	No		

39	Breda	Noord-Brabant	Universal workshop	Yes	1200	0
40	Roosendaal	Noord-Brabant	Universal workshop	Yes	500	0
41	Dongen	Noord-Brabant	Universal workshop	Yes	260	0
42	Goirle	Noord-Brabant	Universal workshop	Yes	200	6
43	Molenschot	Noord-Brabant	Universal workshop	Yes	200	1
44	Oosteind	Noord-Brabant	Universal workshop	Yes	208	1
45	Rijen	Noord-Brabant	Brand workshop	Yes	70	0
46	Rijen	Noord-Brabant	Universal workshop	Yes	260	6
47	'S Gravenmoer	Noord-Brabant	Universal workshop	Yes	50	1
48	Tilburg	Noord-Brabant	Universal workshop	Yes	60	0
49	Tilburg	Noord-Brabant	Universal workshop	Yes	150	0
50	Cruquius	Noord-Holland	Universal workshop	Yes	200	0
51	Haarlem	Noord-Holland	Brand workshop	Yes	50	0
52	Haarlem	Noord-Holland	Brand workshop	Yes	140	0
53	Haarlem	Noord-Holland	Brand workshop	Yes	15	0
54	Haarlem	Noord-Holland	Universal workshop	Yes	10	0
55	Haarlem	Noord-Holland	Universal workshop	Yes	150	4
56	Haarlem	Noord-Holland	Universal workshop	Yes	1250	4
57	Hoofddorp	Noord-Holland	Universal workshop	Yes	500	0
58	Hoofddorp	Noord-Holland	Universal workshop	Yes	200	0
59	Hoofddorp	Noord-Holland	Universal workshop	Yes	100	0
60	Hoofddorp	Noord-Holland	Universal workshop	Yes	300	2
61	Velserbroek	Noord-Holland	Brand workshop	Yes	350	0
62	Velserbroek	Noord-Holland	Brand workshop	Yes	200	0
63	Velserbroek	Noord-Holland	Brand workshop	Yes	500	0
64	Velserbroek	Noord-Holland	Brand workshop	Yes	50	1
65	Velserbroek	Noord-Holland	Universal workshop	Yes	200	0
66	Velserbroek	Noord-Holland	Brand workshop	No		
67	Hoofddorp	Noord-Holland	Universal workshop	No		
68	Haaksbergen	Overijssel	Universal workshop	Yes	200	0
69	Haaksbergen	Overijssel	Universal workshop	Yes	350	15
70	Hengelo	Overijssel	Brand workshop	Yes	360	0
71	Hengelo	Overijssel	Universal workshop	Yes	208	0
72	Hengelo	Overijssel	Universal workshop	Yes	208	0
73	Hengelo	Overijssel	Universal workshop	Yes	156	0
74	Nieuwegein	Utrecht	Brand workshop	Yes	350	5
75	Nieuwegein	Utrecht	Universal workshop	Yes	100	0
76	Nieuwegein	Utrecht	Universal workshop	Yes	260	0
77	Nieuwegein	Utrecht	Universal workshop	Yes	150	1
78	Nieuwegein	Utrecht	Universal workshop	Yes	312	3
79	Nieuwegein	Utrecht	Universal workshop	Yes	520	4
80	Goes	Zeeland	Universal workshop	Yes	100	0
81	Kapelle	Zeeland	Universal workshop	Yes	400	3
82	Kapelle	Zeeland	Brand workshop	No		
83	De Lier	Zuid-Holland	Brand workshop	Yes	350	0
84	Honselersdijk	Zuid-Holland	Universal workshop	Yes	325	0
85	Honselersdijk	Zuid-Holland	Universal workshop	Yes	144	4
86	Maassluis	Zuid-Holland	Brand workshop	Yes	312	0
87	Maassluis	Zuid-Holland	Universal workshop	Yes	72	0

88	Vlaardingen	Zuid-Holland	Brand workshop	Yes	325	0
89	De Lier	Zuid-Holland	Universal workshop	No		

5.2 Desk research data

Nr.	City	Province	Respond / willing to perform	Price incl. taxes
1	Sleen	Drenthe	No	
2	Workum	Friesland	Yes, willing to perform	€ 350.00
3	Ferwerd	Friesland	Yes, vehicle check first	
4	Kollum	Friesland	Yes, willing to perform	€ 475.00
5	's Heerenberg	Gelderland	Yes, willing to perform	€ 350.00
6	Lochem	Gelderland	Yes, not willing to perform	
7	Hengelo	Gelderland	Yes, not willing to perform	
8	Huissen	Gelderland	Yes, not willing to perform	
9	Eerbeek	Gelderland	Yes, vehicle check first	
10	Vorden	Gelderland	Yes, vehicle check first	
11	Harderwijk	Gelderland	No	
12	Nijmegen	Gelderland	No	
13	Winschoten	Groningen	No	
14	Marum	Groningen	Yes, not willing to perform	
15	On location	Nationwide	Yes, willing to perform	€ 300.00
16	Echt	Limburg	No	
17	Heerlen	Limburg	No	
18	Echt	Limburg	No	
19	Tilburg	Noord-Brabant	No	
20	Tilburg	Noord-Brabant	Yes, willing to perform	€ 499.00
21	Eindhoven	Noord-Brabant	Yes, vehicle check first	
22	Eindhoven	Noord-Brabant	Yes, willing to perform	€ 300.00
23	Cuijk	Noord-Brabant	No	
24	Eindhoven	Noord-Brabant	No	
25	Roosendaal	Noord-Brabant	Yes, willing to perform	€ 450.00
26	's Hertogenbosch	Noord-Brabant	No	
27	Oud Gastel	Noord-Brabant	No	
28	Zwanenburg	Noord-Holland	No	
29	Enkhuizen	Noord-Holland	No	
30	Wieringerwerf	Noord-Holland	Yes, not willing to perform	
31	Borne	Overijssel	Yes, willing to perform	€ 399.00
32	Almelo	Overijssel	Yes, willing to perform	€ 380.00
33	Borne	Overijssel	No	
34	Luttenberg	Overijssel	No	
35	Amersfoort	Utrecht	No	
36	Utrecht	Utrecht	Yes, willing to perform	€ 499.00
37	Leusden	Utrecht	No	
38	Houten	Utrecht	Yes, not willing to perform	
39	Utrecht	Utrecht	Yes, willing to perform	€ 300.00
40	Utrecht	Utrecht	No	
41	Halsteren	Zeeland	Yes, willing to perform	€ 300.00
42	Hengstdijk	Zeeland	Yes, willing to perform	€ 590.00
43	Oud-Vossemeer	Zeeland	Yes, willing to perform	€ 650.00

44	Maasdijk	Zuid-Holland	No	
45	Alphen aan den Rijn	Zuid-Holland	Yes, willing to perform	€ 300.00
46	Rotterdam	Zuid-Holland	No	

5.3 Desk research - workshops willing to remove DPF

The below workshops are approached in July 2018.

Nr.	Workshop	Website
1	AVT Chiptuning	http://avt-chiptuning.nl/
2	Chiptuning Noord	https://www.chiptuningnoord.nl/
3	Tunex	https://www.tunex.nl/
4	A1 Tuning	http://a1tuning.nl/
5	Unlimited Tuning Tilburg	https://www.unlimitedtuning.nl
6	GaragePlus	http://www.garagepluseindhoven.com/
7	Cimer	http://cimer.nl/cimer_cartuning.html
8	Roefilter-Verwijderen.com	https://www.roefilter-verwijderen.com/
9	OBD-Chiptuning.nl / verwijderroefilter.nl	https://www.obd-chiptuning.nl/nl
10	AMT Chiptuning	https://amtchiptuning.nl/
11	I drive solutions	https://www.idrivesolutions.nl/
12	R-speed tuning	https://www.rspeedtuning.nl/
13	Tracktune Performance	http://www.tracktune.nl/
14	Auto Service Peene	http://www.asp-auto.nl/
15	Broers Autobedrijf	http://www.broersautobedrijf.nl/index.php/nl/

6 Signature

The Hague, 13 December 2018

A handwritten signature in blue ink, appearing to read 'Staps', with a long horizontal stroke extending to the right.

Ing. Jan Staps (WEL company)
Project leader

TNO

A handwritten signature in blue ink, appearing to read 'N. E. Ligterink', with a circular flourish at the beginning.

Dr. Norbert E. Ligterink
Author