European Roadworthiness Package proposal review

A first review on the emissions sections for the Netherlands

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Samenvatting

Het EU Roadworthiness Package (RWP) is ontwikkeld met als doel dat motorvoertuigen aan de veiligheids- en milieunormen blijven voldoen tijdens het gebruik op de openbare weg. Het RWP, oorspronkelijk aangenomen in 2014, omvat een reeks EU-richtlijnen met betrekking tot de Algemene Periodieke Keuring (APK) en wegkantinspecties. De huidige richtlijnen sluiten niet langer volledig aan op de technologische vooruitgang in moderne voertuigen. Voertuigen met moderne verbrandingsmotoren zijn uitgerust met geavanceerde emissiecontrolesystemen die zorgen voor een lage uitstoot — mits deze systemen goed worden onderhouden, tijdig worden gerepareerd en niet worden gemanipuleerd.
De noodzakelijke bepalingen om ervoor te zorgen dat deze systemen effectief blijven tijdens regulier gebruik ontbreken, waardoor het huidige RWP verouderd is geraakt. Om deze reden heeft de Europese Commissie een uitgebreide herziening van het RWP voorgesteld.
Dit voorstel omvat substantiële wijzigingen die gericht zijn op het verbeteren van de verkeersveiligheid, het bevorderen van duurzaamheid door strengere controles op uitlaatemissies en voertuigconditie, en het aanbrengen van digitale oplossingen om inspectieprocessen en gegevensbeheer te stroomlijnen.

In opdracht van het Ministerie van Infrastructuur en Waterstaat heeft TNO de voorgestelde RWP-onderdelen met betrekking tot de duurzaamheid van motorvoertuigen beoordeeld, waar van toepassing, wordt het voorstel vergeleken met de huidige situatie in Nederland.

De wijzigingen richten zich met name op de uitstoot van luchtverontreinigende stoffen uit de uitlaat, namelijk:

- Nieuwe testmethodieken voor NO_x-controlesystemen en roetfilters.
- Aanscherpingen in omvang en frequentie van de Algemene Periodieke Keuring (APK) en technische controle langs de weg.
- Remote sensing (emissies meten vanaf een afstand) voor het screenen van de vloot, gevolgd door selectie van potentiële hoge uitstoters en gerichte inspecties, hetzij direct langs de weg, hetzij kort erna bij een keuringsstation.

Nieuwe testmethodieken voor NO_x-emissies

Er worden twee NO_x-testmethoden voorgesteld: één voor benzine- en één voor dieselvoertuigen. De methode voor dieselvoertuigen is volledig uitgewerkt, terwijl de versie voor benzinevoertuigen momenteel nog geen details bevat. De test is bedoeld om de werking van het SCR-nabehandelingssysteem (katalysator voor NO_x-reductie) te controleren. De “hot idle NO_x-test” voor dieselvoertuigen bestaat uit een opwarmrit, gevolgd door controle van het SCR-nabehandelingssysteem door middel van het meten van de NO_x-emissies bij stationair draaien. Hierbij wordt een grenswaarde van 40 ppm gehanteerd.
In recent onderzoek zijn belangrijke beperkingen geïdentificeerd voor implementatie van de hot idle NO_x-test binnen de APK. De testmethode is in beperkte mate in staat om problemen te detecteren buiten volledige afschakeling van het SCR-systeem (zoals manipulatie of defecten). Bovendien is de effectiviteit van de test volledig afhankelijk van conditionering voorafgaand aan de test. Aangezien de NO_x-test voor dieselvoertuigen een warme SCR-katalysator vereist, moet de test direct na aankomst bij het keuringsstation worden uitgevoerd. Als de SCR-katalysator al is afgekoeld bij aanvang van de keuring, moet een opwarmrit buiten het keuringsstation plaatsvinden.

Dit sluit slecht aan bij de manier waarop de periodieke keuring in veel lidstaten wordt uitgevoerd. Vanwege de hiervoor beschreven punten is de voorgestelde hot idle NO_x-test voor dieselvoertuigen niet goed geschikt voor de APK.

In het voorstel zijn de voorgeschreven NO_x-testen alleen van toepassing op voertuigen met emissieklasse Euro VI, 6d-temp en nieuwer, hoewel geavanceerde nabehandelingssystemen voor NO_x-emissies al in eerdere modellen voorkomen. Dit is met name relevant voor benzinevoertuigen, aangezien naar verwachting in 2030 deze pre-Euro 6d-TEMP voertuigen nog steeds meer dan 60% van de benzinepersonenauto's in Nederland zullen uitmaken. De testmethoden voor deze benzinevoertuigen, OBD-uitlezing en de gasemissietest, zijn niet effectief in het detecteren van voertuigen met verhoogde NO_x-emissies. Bij de gasemissietest komt dit omdat de relatie tussen NO_x-emissies in de praktijk (rijdend) en testemissies onder keuringsomstandigheden (stationair draaien) zwak is. Om de effectiviteit te bevorderen, zal een nieuwe NO_x-testmethode voor benzinevoertuigen waarschijnlijk motorbelasting of dynamische rijomstandigheden moeten bevatten.

Nieuwe testmethoden voor deeltjesaantallen-emissies

Net als bij de NO_x-test worden er twee testmethoden voor deeltjesaantallen voorgesteld: één voor benzine- en één voor dieselvoertuigen. De methode voor dieselvoertuigen is volledig uitgewerkt, terwijl de versie voor benzinevoertuigen gedeeltelijk is gespecificeerd. De test is bedoeld om de werking van roetfilters te controleren. De deeltjestest voor dieselvoertuigen uitgerust met roetfilters is reeds succesvol geïmplementeerd in verschillende Europese lidstaten, waaronder Nederland. Deze test is aantoonbaar effectief in het opsporen van defecte of verwijderde roetfilters. De voorgestelde grenswaarde sluit aan bij aanbevelingen uit eerder onderzoek en zal de momenteel geldende grenswaarde in Nederland verder aanscherpen.

Voor benzinevoertuigen is de voorgestelde testmethode in de basis grotendeels gelijk aan de dieselvariant. Eerste ervaringen met het gebruik van voor dieselvoertuigen ontwikkelde deeltjestellers bij benzinevoertuigen tonen goede resultaten. Daarentegen tonen dezelfde studies ook grote variaties in de gemeten deeltjesconcentraties tussen verschillende benzinevoertuigen. Meer data van gemeten deeltjesaantallen van benzinevoertuigen en onderliggende afhankelijkheden zijn nodig om een robuuste en effectieve grenswaarde te ontwikkelen. Deze waarde moet foutpositieve uitkomsten vermijden en het aantal foutnegatieve uitkomsten minimaliseren.

Aangescherpt keuringsinterval

Op dit moment hanteert Nederland al aanzienlijk strengere keuringsintervallen voor lichte en zware wegvoertuigen dan in de huidige EU richtlijnen wordt voorgeschreven. Het nieuwe RWP voorstel intensiveert het EU keuringsinterval door jaarlijkse keuringen te verplichten vanaf tien jaar na voertuigregistratie. Dit verkleint het verschil tussen de EU en Nederland aanzienlijk, al verdwijnt deze niet volledig. Het voorstel bevat tevens aanvullende emissietesten voor N1-voertuigen (bestelbussen) in de eerste drie jaar na registratie. Dit is hoogstwaarschijnlijk inefficiënt, aangezien voertuigemissies doorgaans stijgen met toenemende leeftijd en kilometerstand. Gegevens uit APK deeltjestesten in Nederland en NO_x-resultaten uit plume chasing door TNO laten zien dat verouderingseffecten en/of defecten bij roetfilters en SCR-katalysatoren in de eerste drie jaar niet worden verwacht. Extra inspanningen om verouderingseffecten en defecten op te sporen zijn het meest toepasselijk bij oudere voertuigen, niet bij nieuwere exemplaren tot drie jaar oud.

Remote sensing voor het detecteren van hoge uitstoters

Er zijn twee varianten van remote sensing voor uitlaatemissies. De eerste is point sampling, waarbij uitlaatgaspluimen worden gemeten langs of boven een weg op vaste locaties. De tweede is plume chasing, waarbij een meetvoertuig op de weg rijdt en de uitlaatpluimen van het voertuig ervoor bemonstert. Voor point sampling zijn twee marktklare systemen bij TNO bekend: HEAT EDAR, geplaatst boven het verkeer, en OPUS RSE, geplaatst naast het verkeer. Voor plume chasing is slechts één marktklaar systeem gevonden: Airyx Plume Chasing, geïnstalleerd in een meetvoertuig. Het belangrijkste voordeel van point sampling ten opzichte van plume chasing is de mogelijkheid om emissies van een groot aantal voertuigen te meten in een korte periode, meestal minder dan een seconde per voertuig. Plume chasing daarentegen biedt een nauwkeurigere meting van de voertuigemissies, waarbij enkele minuten per voertuig wordt gemeten. Voor een succesvolle meting vereist plume chasing een minimale rijsnelheid, doorgaans alleen haalbaar op landelijke wegen en snelwegen. Point sampling werkt het beste bij lichte hellingen.

Er zijn ook enkele aandachtspunten. Op dit moment biedt slechts een beperkt aantal leveranciers remote sensing-meetapparatuur aan. Daarom is het belangrijk dat in het kader van het RWP voorstel een overzicht wordt gemaakt van de huidige (en potentiële) beschikbaarheid van leveranciers van remote sensing-apparatuur en hun respectievelijke leveringscapaciteit. Ten tweede mogen volgens het voorstel remote sensing metingen op verschillende locaties worden uitgevoerd. Dit vereist dat de meetresultaten vergelijkbaar en uitwisselbaar zijn, en als de resultaten worden gebruikt voor het selecteren van voertuigen met potentieel verhoogde emissies, dan moeten de remote sensing methoden even selectief zijn. Standaardisatie en certificering van remote sensing apparatuur en meetprocedures voor remote sensing zijn van groot belang voor het succes van de vlootscreening en moeten in het voorstel worden opgenomen. Ten derde wordt het meten van NO_x grotendeels afgedekt door alle drie de beschikbare remote sensing systemen, maar niet het meten van deeltjesemissies. Verdere ontwikkeling van deeltjesmetingen voor remote sensing is noodzakelijk om tijdens het screenen van de vloot een goede detectie van voertuigen met potentieel verhoogde emissies te kunnen bieden.

Vlootscreening

Een methode om hoge uitstoters op te sporen is door systematische screening op emissies van het wagenpark met behulp van remote sensing. Het RWP voorstel bevat een jaarlijks screeningsdoel van 30% van de geregistreerde motorvoertuigen. Dit komt voor Nederland neer op ten minste 3,4 miljoen voertuigen per jaar. Op basis hiervan, in combinatie met geschatte meetcapaciteiten van point sampling en plume chasing, heeft TNO de benodigde apparatuur voor de Nederlandse situatie geschat. Het behalen van het doel met uitsluitend plume chasing zou 137 plume chase-voertuigen vereisen, en met point sampling tussen 1 en 7 locaties. Met behulp van een slimme combinatie van point sampling en plume chasing zou een hogere efficiëntie behaald kunnen worden in het detecteren van voertuigen met potentieel verhoogde emissies. De meetnauwkeurigheid en efficiëntie van voertuigselectie kunnen verder worden verbeterd door meerdere point sampling stations op dezelfde weg te installeren. Deze stations moeten enkele kilometers uit elkaar geplaatst worden.

Voor de kosten van plume chasing- en point samplingcampagnes zijn ruwe eerste schattingen gemaakt. Voor een meer nauwkeurige en complete kostenraming zijn gedetailleerdere berekeningen nodig. Voor point sampling metingen worden kosten verwacht tussen €0,20 en €1,20 per gemeten voertuig. Uitgaande van €0,60 per voertuig komt dit neer op een jaarlijks bedrag tussen de €2 miljoen en €3 miljoen om het vlootscreeningsdoel te behalen.

Voor plume chasing worden de kosten geschat op €468.000 per jaar per plume chase voertuig. De Europese Commissie presenteerde kostenramingen voor remote sensing die aanzienlijk lager waren dan de schattingen van leveranciers van remote sensing-apparatuur.

Selectie van potentiële hoge uitstoters op basis van vlootscreening

Data vanuit vlootscreening dient als basis om potentiële hoge uitstoters te selecteren en deze te onderwerpen aan verificatietesten. Het RWP voorstel bevat een selectiecriterium voor hoge uitstoters, namelijk: voertuigen die meer dan het dubbele uitstoten van het gemiddelde emissieniveau van voertuigen binnen dezelfde voertuigcategorie, emissieklasse en ontstekingstype. De daadwerkelijke selectie is gebaseerd op ten minste drie metingen binnen een periode van zes maanden. Hoewel de methodiek voor het vaststellen van het gemiddelde emissieniveau nog niet is gedefinieerd in het voorstel, wordt in dit rapport aanbevolen om hiervoor de vlootscreening data te gebruiken. Dit zorgt ervoor dat emissieniveaus worden vastgesteld onder representatieve omstandigheden en maakt het mogelijk om de drempelwaarde voor hoge uitstoters in de loop van de tijd aan te passen aan veranderingen in de vlootemissies.

Op basis van recente inzichten uit plume chasing door TNO in Nederland wordt verwacht dat ongeveer 8% van de voertuigen de in het RWP voorgestelde drempel overschrijdt. Dit komt omgerekend neer op ten minste 272.000 potentiële hoge uitstoters per jaar. Gezien het grote aantal voertuigen dat bij invoering van het RWP verificatietesten zou moeten ondergaan, kan een gefaseerde aanpak worden overwogen. Dit zou het aantal geselecteerde voertuigen aanvankelijk beperken en afstemmen op de capaciteit. Daarnaast kan een minimale absolute drempelwaarde worden ingevoerd. Dit voorkomt dat voertuigen met lage emissies worden geselecteerd in toekomstige scenario's waarin het gemiddelde emissieniveau zeer laag wordt. In dergelijke gevallen zou de factor twee drempel onbedoeld voertuigen met lage emissies kunnen meenemen in de hoge uitstoter selectie.

Effectieve verificatie van hoge uitstoters

Om het volledige potentieel van het voorgestelde RWP te realiseren, dienen de voertuigselectie via remote sensing en verificatietests (kosten)effectief te zijn en zich uitsluitend te richten op voertuigen met verhoogde emissies. Een belangrijk element in de effectiviteit is het harmoniseren van de remote sensing technieken met de selectiecriteria voor hoge uitstoters en de verificatiemethoden.

Bij het selecteren van voertuigen met hoge emissies op basis van remote sensing zouden de volgende voorwaarden moeten gelden:

- Vlootscreening en verificatietesten meten dezelfde parameters, bij voorkeur onder vergelijkbare omstandigheden.
- De selectiegrens voor hoge uitstoters is minder streng dan de verificatiegrens.
- De tijd tussen de laatste remote sensing-meting en de verificatietest is kort.

Bijvoorbeeld: in het geval van benzinevoertuigen met een emissieklasse tot Euro 6d-temp bestaat het reële risico dat bij voertuigen hoge NO_x-emissies worden gedetecteerd tijdens vlootscreening, maar dat deze niet kunnen worden gemeten in de verificatietesten. Het voorstel dient te beschrijven hoe er met deze situaties moet worden omgegaan.

Als alternatief zouden verificatiemethoden kunnen worden losgekoppeld van de testmethoden voor de APK en wegkantcontrole. De randvoorwaarden van APK beperken de testmethoden immers aanzienlijk.

Moderne nabehandelingssystemen zijn ontworpen voor het rijden in een laboratorium en op de weg, niet voor stationair draaien bij een garage. De verificatietesten dienen deze rijomstandigheden daarom zo goed mogelijk na te bootsen.

Voorbeelden van alternatieve verificatiemethoden zijn:

- Grondige visuele inspectie gericht op goedgekeurde emissiecontrolesystemen.
- Testen onder belasting met een (vereenvoudigde) rollenbank.
- Testen op de weg met mobiele emissiemeetapparatuur aangesloten op de uitlaat van het voertuig.
- Plume chasing in een gecontroleerde omgeving, zoals een testbaan.

Wegkantcontrole

Een andere methode om hoge uitstoters in het wagenpark op te sporen is door het uitvoeren van wegkantcontroles. Het RWP voorstel bevat jaarlijkse nationale doelstellingen voor wegkantcontrole van zware voertuigen (HDV) en lichte bedrijfsvoertuigen (LCV), namelijk respectievelijk 5% en 2% van het wagenpark. Voor Nederland betekent dit dat jaarlijks ten minste 10.800 HDV's en 21.000 LCV's aan wegkantcontrole worden onderworpen.

De voorgestelde doelstellingen richten zich uitsluitend op het staande houden van voertuigen. Het zou echter effectiever zijn om in de doelstellingen ook plume chase metingen uitgevoerd vóór het stoppen van het voertuig op te nemen. Wegkantcontroles zouden zich immers moeten richten op voertuigen die vermoedelijk een te hoge uitstoot hebben. Plume chasing maakt het mogelijk om deze vermoedens te bevestigen of te weerleggen door de emissies op afstand te meten. Deze aanpak maakt gerichtere wegkantcontrole mogelijk voor voertuigen met vermoedelijk hoge emissies en minimaliseert het onnodig langs de weg stilzetten van goed functionerende voertuigen.

De diesel hot idle NO_x-testmethode en de bijbehorende vereiste testomstandigheden sluiten goed aan bij wegkantcontrole, idealiter wordt deze test gecombineerd met plume chasing. Deze aanpak maakt effectieve selectie van voertuigen met potentieel verhoogde NO_x-emissies mogelijk, gevolgd door directe verificatie langs de weg met de diesel hot idle NO_x-test. Dit zorgt ervoor dat het nabehandelingssysteem de vereiste temperatuur bereikt en behoudt tot aan de start van de hot idle test. Bovendien is het detecteren van gedeactiveerde SCR-systemen, hetzij defect of gemanipuleerd, een belangrijke sterkte van deze testmethode en een van de belangrijkste doelen van wegkantcontrole.

Samenvatting van de belangrijkste aanbevelingen ten behoeve van de verbetering van het RWP voorstel

De Commissie heeft een voorstel ingediend om het RWP te actualiseren en te verbeteren. Het voorstel behandelt veel relevante onderwerpen, er zijn echter nog diverse openstaande- en/of verbeterpunten.

Om de effectiviteit en efficiëntie van het RWP verder te versterken, doet TNO de volgende aanbevelingen:

- Verbetering van NO_x- en PN-testmethoden:
  - Ontwikkel een robuuste NO_x-test voor benzinevoertuigen. Het is van belang om daarin motorbelasting op te nemen, aangezien NO_x-testen bij stationair draaien een zwakke correlatie vertonen met NO_x-emissies in de praktijk.

- Neem NO_x-tests op voor voertuigen van vóór Euro 6d-TEMP.
- Finaliseer de PN-testmethode voor benzinevoertuigen en stel een betrouwbare grenswaarde vast om foutpositieve en foutnegatieve resultaten te voorkomen.

- Een versterking van het kader voor remote sensing:
  - Standaardiseer en certificeer remote sensing apparatuur en meetprocedures.
  - Breid de mogelijkheden voor het meten van deeltjesemissies uit.
  - Valideer kostenramingen.
  - Gebruik een efficiënte combinatie van point sampling en plume chasing.
- Verbetering van de vlootscreening:
  - Gebruik data van vlootscreening om drempelwaarden vast te stellen.
  - Voer een minimale absolute drempel in en pas een gefaseerde aanpak toe voor verificatietesten.
- Zorg voor harmonisatie van de remote sensing technieken met de selectiecriteria voor potentiële hoge uitstoters en de verificatietestmethoden. Het is van groot belang om te voorkomen dat er selectie plaatsvindt van niet-hoge uitstoters en selectie van hoge uitstoters die onopgemerkt blijven tijdens verificatietests.
  - Vlootemissiescreening en verificatietests meten dezelfde parameter, bij voorkeur onder vergelijkbare omstandigheden.
  - De selectiedrempel voor hoge uitstoters is minder streng dan de verificatie drempelwaarde.
  - De doorlooptijd tussen de laatste remote sensing-meting en de verificatietest is beperkt.
- Afstemming van verificatietesten op praktijkomstandigheden: ontkoppel verificatietestmethoden van beperkingen vanuit APK en wegkantcontrole door alternatieve methoden te onderzoeken, zoals testen op een eenvoudige rollenbank, testen op de weg en plume chasing in gecontroleerde omgeving.
- Integratie van plume chasing in wegkantcontrole voor gerichte inspecties, tel elke plume chase mee als een inspectie en combineer deze met diesel hot idle NO_x-testen.

Summary

The EU Roadworthiness Package (RWP) is designed with the goal to ensure that motor vehicles remain safe and compliant while operating on public roads across the European Union. Originally adopted in 2014, the package comprises a set of EU Directives governing periodic technical inspections and roadside inspections. The current framework is no longer fully aligned with the technological advancements in modern vehicles. Vehicles with modern internal combustion engines are equipped with advanced emission control systems that keep them clean—provided these systems are properly maintained, promptly repaired, and not tampered with. The necessary provisions were lacking to ensure these systems remain effective during regular use and therefore the current RWP became outdated. In response, the European Commission has proposed a comprehensive revision of the RWP. This proposal introduces substantial amendments aimed at enhancing road safety, improving environmental sustainability through stricter control of emissions and vehicle conditions, and promoting digital solutions to streamline inspection processes and data management.

On behalf of the Dutch Ministry of Infrastructure and Water Management, TNO evaluated the proposed RWP sections concerning the environmental sustainability of motor vehicles. Where applicable, the proposal is compared to the current situation in the Netherlands.

The changes mainly target pollutant emissions from the exhaust:

- New testing methods for NO_x-control systems and particle filters.
- Improvements in scope and frequency for periodical technical inspection (PTI) and roadside inspection (RSI).
- Remote sensing for fleet screening, followed by selection of potential high emitters and targeted inspections conducted either directly at the road-side or shortly after selection at a PTI station.

New testing methods for NO_x-emissions

Two NO_x-test methods are proposed: one for petrol and one for diesel vehicles. The method for diesel vehicles is presented in full, while the petrol version is currently still blank. The diesel hot idle NO_x-test consists of a warm-up drive followed by checking the SCR aftertreatment system through measuring the NO_x-emissions at idle, with a limit value of 40 ppm. A recent study identified significant challenges for implementation in PTI. The test method’s limited ability to detect issues beyond deactivation of the SCR aftertreatment system (e.g. tampered or broken). Moreover, the effectiveness of the test method is fully dependent on proper preconditioning. As the PTI NO_x-test for diesel requires a hot catalyst, the test needs to be done immediately after arrival at the PTI station. If the SCR catalyst has already cooled down when starting the PTI, a warm-up ride outside the PTI station must be performed. As these conditions reconcile very poorly with the way the PTI is done in many Member States, the diesel hot idle NO_x-test is not well suited for PTI.

In the proposal, NO_x testing is only applicable to motor vehicles with an emission class of Euro VI, 6d-temp and newer, even though advanced aftertreatment systems for NO_x-emissions can already be found in earlier models.

This is especially important for petrol vehicles, as in 2030 these pre-Euro 6d-TEMP vehicles are expected to still represent more than 60% of the petrol passenger cars in the Netherlands. The applicable testing methods for these vehicles, that is OBD read-out and the gaseous emissions test, have shown to be unable to properly detect NO_x-high emitters. For the gaseous emissions test this is because the relationship between real-world NO_x-emissions during driving and test emissions obtained under PTI conditions (idle) has shown to be weak. To be effective, a new NO_x-test method for petrol vehicles will most likely need to incorporate engine load conditions or dynamic driving conditions.

New testing methods for Particle Number emissions

Similar to the NO_x-test, two Particle Number test methods are proposed: one applicable to petrol and the other to diesel vehicles. The method for diesel vehicles is presented in full, while the petrol version is partially specified. The particle number test for diesel vehicles equipped with diesel particle filters has already been successfully implemented in several European Member states, including the Netherlands. This test has proven to be an effective method to detect failures or removal of diesel particle filters. The proposed limit value aligns with recommendations from research. This limit will further tighten the limit value currently in force in the Netherlands.

For petrol vehicles the basic concept of the test method mirrors that of the diesel variant. Initial findings on using diesel PN-PTI equipment for petrol vehicles show promising results. However, the same studies also show large variations in particle concentrations across different petrol vehicles. More data on particle number concentrations from petrol vehicles and their dependencies are necessary to develop a robust and effective limit value.
This value should avoid false positives and minimize false negatives.

Tightened interval for periodic technical inspections

Currently, the Netherlands has already a significantly more stringent regime regarding intervals for Periodic Technical Inspections for LDV and HDV than the EU directives prescribe. The new proposal improves the PTI interval to annual inspections starting 10 years after vehicle registration. This largely closes the gap between EU and NL, though not entirely.
The proposal also includes additional emissions testing for N1 vehicles in the first three years after vehicle registration. This is likely inefficient, as vehicle emissions generally tend to increase with age and mileage. Data from PN PTI testing in the Netherlands and plume chasing NO_x-results from TNO indicate that problems with particulate filters and SCR catalysts are not expected in the first three years. Additional efforts to reveal deterioration and malfunctions perform best when targeting older vehicles, not the newest ones up to three years old.

Remote emissions sensing equipment for detecting high emitters

There are two variants of remote sensing for exhaust emissions. The first is point sampling, where exhaust gas plumes are measured along or above a road at fixed locations.
The second is plume chasing, where a measurement vehicle drives on the road and samples the exhaust plumes of the vehicle in front. For point sampling two market ready systems are found in this study: HEAT EDAR, placed above traffic, and OPUS RSE, placed next to traffic. For plume chasing only one market ready system is found: Airyx Plume Chasing, installed inside a measurement vehicle. The main advantage of point sampling over plume chasing is its ability to measure emissions from a large number of vehicles for a short timeframe, typically less than a second per vehicle. In contrast, plume chasing provides a more accurate measurement of the vehicle's emissions, captured over an extended period of a few minutes per vehicle.

For a successful measurement, plume chasing requires a minimum speed, typically achieved in rural and motorway driving. Point sampling works best under slight road inclination conditions.

There are also some points that require attention. At the time of writing, only a limited number of suppliers offer remote sensing measurement equipment. Therefore, it is important that the proposal includes a review of the current (and potential) availability of remote sensing equipment suppliers and their respective supply capacity. Secondly, according to the proposal remote sensing measurements may be collected across various locations. This requires measurement results to be comparable, and if results are to be used for selection for evaluative testing, the methods must be equally selective. Standardization and certification of remote sensing equipment and measurement procedures for remote sensing are critical to the success of the fleet screening approach and need to be included in the proposal. Thirdly, remote measurement of NO_x is mostly covered by all three available remote sensing systems, however measurement of particle number emissions is not. Further development of remote sensing particle emission techniques is necessary to provide proper potential high emitter detection during fleet screening.

Fleet emissions screening

One method for facilitating high emitter detection is by systematically screening the fleet on emissions by means of remote sensing. The proposal includes a yearly screening target of 30% of the registered motor vehicles, which translates to a target of at least 3.4 million vehicles for the Netherlands. Based on this target and estimated vehicle measurement rates of point sampling and plume chasing, TNO estimated the required equipment for the Dutch situation. Reaching the target by exclusively employing plume chasing would require 137 plume chase vehicles, and for point sampling between 1 and 7 locations. Using a strategic combination of point sampling and plume chasing could allow for more efficiently selecting potential high emitters than with just one methodology. Measurement accuracy and vehicle selection efficiency can be improved by installing multiple point sampling stations on the same road. These stations should be spaced a few kilometres apart.

For the costs for plume chasing and point sampling campaigns some rough first estimates were made. For a fully accurate and complete estimation of the total cost more detailed calculations are needed. For point sampling measurements, costs are expected between €0.20 and €1.2 per measured vehicle. Taking €0.60 per measured vehicle would result in a total yearly cost between €2 million and €3 million to reach the fleet screening target. For plume chasing, costs are estimated at €468k per year per plume chase vehicle. The European Commission also presented estimates for remote sensing that were at least many times lower than estimates given by remote sensing suppliers.

Potential high emitter selection from fleet emission screening

Fleet screening data is used to select potential high emitters and submit them to verification testing. The proposal defines a potential high emitter selection criterium of more than double the average emissions levels for vehicles belonging to the same vehicle category, emission class and ignition type. Selection is based on at least three measurements within a six month period. Although the determination of the average emissions level is still undefined in the proposal, in this report it is recommended to use the fleet screening data for this. This would ensure that emission levels are established under representative conditions and it allows for changes in the high emitter threshold over time corresponding to the changes in the fleet emissions.

Based on recent plume chase insights from TNO in the Netherlands, around 8% of vehicles are expected to exceed the threshold. This corresponds to at least 272,000 potential high emitter vehicles per year. Given the large number of vehicles expected to require verification testing, a staged approach could be considered. This would limit the number of selected vehicles initially and help manage capacity more effectively. Additionally, a minimum absolute threshold value could be introduced. This would prevent low-emitting vehicles from being flagged in future scenarios where the average emissions become very low. In such cases, the factor 2 threshold might unintentionally include low emitting vehicles in the selection.

Effective high emitter verification testing

To fully realise the potential of the proposed updated RWP, vehicle selection through remote sensing and verification testing need to be (cost-) effective and targeting high emitters only. A key element in the effectiveness is the harmonization of the remote sensing techniques with the high emitter selection criteria and the verification testing methods.

In case of suspected high emissions based on remote sensing, the following conditions should be met:

- Fleet emissions screening and verification testing must measure the same parameter, preferably under similar conditions.
- The potential high emitter selection threshold should be less stringent than the verification threshold.
- Lead time between the last remote sensing measurement and verification testing should be kept short.

For example in the case of petrol vehicles with an emissions class up to Euro 6d-temp, there is a real risk of being able to detect NO_x-high emitters during fleet screening while being unable to verify high NO_x-emissions in verification testing. The proposal needs to include how to handle these conditions.

Alternatively, verification testing methods could be separated from the methods of testing for PTI and RSI. The conditions of the PTI significantly constrict the boundary conditions that the methods of testing have to adhere to. Modern aftertreatment systems are designed for driving in the lab and on the road, not for idling at an automotive repair centre. Therefore the most accurate verification tests should replicate driving conditions as closely as possible.

Examples of alternative methods for verification testing include:

- Thorough visual inspection focused on approved emissions control components.
- Testing under load using some form of (simplified) chassis dynamometer.
- On-road testing with mobile emission measurement equipment connected to the vehicle exhaust.
- Plume chasing in a controlled environment, such as a test track.

Roadside Inspection

Another method for detecting high emitters in the fleet is by performing RSI. The proposal contains annual national targets for RSI of HDV and LCV, which are 5% and 2% of the fleet respectively. For the Netherlands this would result in at least 10,800 HDV and 21,000 LCV being subjected to RSI each year.

The proposed targets only focus on stopping vehicles. However, it would be more effective to include plume chasing measurements before stopping the vehicle.

RSI should target vehicles suspected of high emissions. Plume chasing allows these suspicions of high emissions to be confirmed or rejected by simply driving behind the vehicle and measuring its emissions. This approach enables more targeted RSI for vehicles suspected of high emissions and minimizes unnecessary stops of properly functioning vehicles.

Additionally, since the diesel hot idle NO_x-testing method and its required conditions align well with RSI, it should be combined with plume chasing. This approach enables effective selection of NO_x-high emitters, followed by immediate roadside verification using the diesel hot idle NO_x test. This ensures that the aftertreatment system reaches and maintains the required temperature until the hot idle test is actually started. Moreover, detecting deactivated SCR systems, either broken or manipulated, is a key strength of this test method and one of the important purposes of RSI.

Summary of key recommendations to improve the RWP proposal

The commission issued a proposal to update and improve the RWP. The proposal addresses many relevant topics, but still leaves a number of matters unresolved.

To further strengthen the effectiveness and efficiency of the RWP, TNO has the following recommendations:

- Improve NO_x-and PN-testing methods:
  - Develop a robust NO_x-test for petrol vehicles that includes engine load conditions, as idle-based tests show weak correlation with real-world NO_x-emissions.
  - Include NO_x-testing for pre-Euro 6d-TEMP vehicles.
  - Finalise PN-test method for petrol vehicles and establish a reliable limit value to avoid false positives and negatives.
- Strengthen the remote sensing framework:
  - Standardize and certify remote sensing equipment and procedures.
  - Expand capability to measure particle emissions.
  - Validate cost estimates.
  - Use a mix of point sampling and plume chasing for efficiency.
- Enhance fleet screening:
  - Use fleet screening data to set thresholds.
  - Introduce a minimum absolute threshold and apply a staged approach for verification testing.
- Ensure harmonization of the remote sensing techniques with the selection criteria for potential high emitters and the verification testing methods. It is of great importance to prevent selection of non-high emitters and selection of high emitters that go undetected during verification testing.
  - Fleet emissions screening and verification testing measure the same parameter, preferably under similar conditions.
  - The high emitter selection threshold is less stringent than the verification threshold.
  - Lead time between the last remote sensing measurement and verification testing is limited.
- Align verification testing with real driving conditions: separate verification testing methods from PTI and RSI constraints by exploring alternative methods such as chassis dyno, on-road testing, and controlled environment plume chasing.
- Integrate plume chasing into RSI for targeted inspections, count every plume chase measurement as an initial inspection, and combine it with diesel hot-idle NO_x-testing.

Contents

1 Introduction

1.1 Background

The EU roadworthiness package (RWP) needs to ensure that motor vehicles remain roadworthy when they are in-use on public roads in the EU. The EU's 'roadworthiness package' consists of three directives covering: periodic roadworthiness tests (PTI), technical roadside inspections of commercial vehicles (RSI) and vehicle registration documents. It has been in force since 20 May 2018. The PTI and RSI measures are to check regularly if vehicles are roadworthy with regard to safety and the environment and require vehicle owners to repair the vehicle when roadworthiness isn't met.

The current RWP, which originally dates from 2014 is outdated and needs to be modernized. The EC reports, amongst others: "…Some of the tests used in today's Periodic Technical Inspections (PTI) are no longer sensitive enough to detect emission failures of modern vehicles, and the current testing procedures are not fit to meet the EU policy goals for air pollution and noise…"

In April 2025, the EC therefore proposed a revision of the roadworthiness package. The proposal contains significant amendments to the current RWP, aimed at enhancing road safety, improving environmental sustainability and promoting digital solutions. For environmental sustainability, there are two EU directives in force from the 2014 RWP which are amended:

1. (PTI) Directive 2014/45/EU on periodic roadworthiness tests requires that road transport vehicles are periodically tested to ensure compliance with a set of minimum requirements. It applies to all cars, vans, trucks, buses, heavy trailers, faster tractors, and since January 2022, larger two- and three-wheel vehicles and quadricycles.

2. (RSI) Directive 2014/47/EU on technical roadside inspections complements Directive 2014/45/EU by requiring Member States to carry out roadside inspections of heavy passenger and freight vehicles and their trailers.

The Dutch Ministry of Infrastructure and Water Management (IenW) has requested TNO to review the sections of the roadworthiness package proposal regarding pollutant emissions. The findings of this first review are reported here.

1.2 Readers guide

This report starts off with an overview of the proposes changes to the RWP, followed by the methods of testing and PTI. Furthermore, the fleet emissions screening, verification testing and RSI are discussed, and finally the conclusions are presented. Additional details can be found in the appendices.

2 Proposed changes to the RWP

The proposal and it's annexes[1] amend Directive 2014/45/EU on periodic roadworthiness tests for motor vehicles and their trailers and Directive 2014/47/EU on the technical roadside inspection of the roadworthiness of commercial vehicles circulating in the Union.

The proposal contains the following main changes which are relevant for environmental sustainability of motor vehicles.

These changes mainly target pollutant emissions from the exhaust:

- New exhaust gas tests are added:
  - Hot idle NOx-test for diesel. For motor vehicles CI (diesel) Euro VI, 6d-temp and newer.
  - NOx-test for petrol. For motor vehicles PI (petrol) Euro VI, 6d-temp and newer.

  This requires test centres to be equipped with the device needed to measure nitrogen oxides.
  - Particle Number (PN) test. For motor vehicles CI (diesel) Euro 5b, VI and newer.
  - Particle Number (PN) for PI (petrol) VI, 6c and newer for vehicles with PN limit. This includes petrol cars with a Gasoline Particle Filter.

  This requires test centres to be equipped with the device needed to measure particle numbers.
- New systematic use of remote sensing for fleet emissions screening is added, complemented by an annual national target of 30% of the national fleet.
  - Remote sensing is to be used for pre selection of potential high emitters of which emissions need to be verified, either immediately at road side inspection or later, within 15 days, at a PTI test station. High-emitters are defined as vehicles having more than double the average exhaust emissions level of similar vehicles. Screening is implemented for the entire fleet, also emissions classes that do not receive new exhaust gas tests.

Additionally, changes are proposed for the scope, frequency and information:

- Frequencies of periodic inspection are increased for some categories:
  - for passenger cars (M1) and vans (N1), after 10 years the frequency becomes one year instead of two and
  - for vans, additional yearly emissions PTI from the first year after registration.

[1] Roadworthiness package Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT OF THE COUNCIL amending Directive 2014/45/EU on periodic roadworthiness tests for motor vehicles and their trailers and Directive 2014/47/EU on the technical roadside inspection of the roadworthiness of commercial vehicles circulating in the Union, Brussels, 24.4.2025 COM(2025) 180 final, 2025/0097 (COD) and Annexes 1 to 2.

- The scope for road-side inspection is extended from just HDV to vans (N1). A target is set at member state level to inspect at least 2% of the total number of vans registered in the member state. The target of 5% for heavy duty will remain the same.
- Periodic technical inspection becomes mandatory for category L (motorcycles > 125 cm^3 or > 11 kW).
- A roadworthiness test is required if the safety or environmental systems and components of the vehicle have been significantly altered.
- A paragraph to provide for effective penalties for obvious tampering or manipulation of vehicle components, including emission control systems.
- In addition the Commission shall adopt implementing acts to specify the set of technical information necessary for roadworthiness testing. This would enable better evaluation of diagnostic trouble codes, software version, etc.).

More details on and a visual presentation of the changes to RSI and PTI proposed in the RWP can be found in Appendix B.

3 Methods of testing and PTI

In this chapter the proposed improvements in the methods of testing are discussed, predominantly in the context of the PTI, and the proposed changes to the PTI intervals.

3.1 Additional methods of testing

Diesel PN-test

The proposal contains a procedure for the diesel exhaust gas measurement of the particle number concentration and proposes limit values as well. The method for the measurement of particle number of diesel vehicles is a new item for many Member States. The particle number test for diesel vehicles with diesel particle filters has already been successfully implemented in several European Member states, among which the Netherlands, and is an effective method to detect failures or removal of diesel particle filters.

Research [1] shows that the proposed limit of 250,000 #/cm^3 for compression ignition engines of Euro 5b and newer, VI and newer is a good threshold because data shows that a small fraction of the vehicles emit PN concentrations around this value, most are either well below or well above. According to the proposal, Member States may apply a limit value up to 1,000,000 (#/cm^3) for vehicles up to emission class Euro 5a and Euro V, equipped with particle filters.

Diesel hot idle NO_x-test

The proposal contains a procedure for the diesel exhaust gas measurement of the NO_x-concentration and a limit value for the NO_x-concentration of 40 ppm. The test method for NO_x-measurement of diesel vehicles is a new item and will not apply for diesel vehicles older than Euro 6d temp and Euro VI. The test involves a preconditioning drive prior to the test of at least five minutes. Just after the preconditioning drive, the NO_x-concentration in the exhaust gas has to be measured when the engine and aftertreatment systems are supposed to be at working temperature. A test results in a fail if the NO_x-concentration exceeds the limit value of 40 ppm.

The test has been designed to identify a fully deactivated SCR system, e.g. in case of tampering or complete failure.

A recent study [2] showed that the test would not be sensitive enough to detect deterioration of the SCR resulting in partially reduced performance. The test isn't performed under load and can therefore be passed easily, since only EGR and just little SCR activity would be needed to achieve the required NO_x-concentrations below 40 ppm. Additionally, the test results are highly dependent on the preconditioning of the SCR system, while sufficiently heating up the SCR to operating temperatures sometimes proved to be challenging for larger vehicles and test locations surrounded by slow speed roads. It was also concluded that the need to drive the vehicle prior to the test adds complexity and burden to the PTI and for some member states a test drive may not even be possible.

Taking this into account, the diesel hot idle NO_x-test is not well suited for the PTI. However, for RSI the applicability of the test method is much more favourable. This is discussed further in Chapter 4.5.

Petrol PN test

The proposal contains a partially finished procedure for measurement of PN. Additional details of the test procedure and limit value need to be specified. Modern petrol vehicles with direct injection engines are equipped with gasoline particulate filters (GPF), similar to their diesel counterparts. A PN-test has already been deemed feasible for diesel engines with diesel particle filters and it is therefore a logical step to implement a similar testing method for petrol vehicles. The objective of the test is to check the state and/or presence of the particle filter by measuring the particle emissions in the exhaust gas. Although initial findings [1] [3] on using diesel PN-PTI equipment for petrol vehicles show promising results, the same studies also show large variations in particle concentrations between measurements of different petrol vehicles. More data of particle number concentrations from petrol vehicles and their dependencies are necessary to formulate a robust and effective limit value, i.e. one that avoids false positives and minimizes false negatives.

It is known that diesel particle filters sometimes crack or are removed, the latter mainly to avoid costs of replacement. Both lead to severely elevated PM and PN-emissions similar to that of decades old vehicles. These cases can easily be detected by the PN-test. For the GPF however, there is limited information on real-world durability issues, filter removal, and the respective occurrence of both. The DIAS-project[2] reported the existence of GPF manipulation devices enabling the removal of the GPF, most probably done with the goal of 'tuning', i.e. increasing the power and of the engine and/or the exhaust sound. Without any statistics on malfunctions or tampering of GPF's it remains uncertain what the exact emissions reduction potential of a PN-test for petrol cars with GPFs will bring. Furthermore, it is uncertain whether the PN measuring instruments currently used for diesel cars are also suitable for gasoline cars. A possible factor here is that a gasoline PN-meter must be equipped with a heated line, while this is not required for diesel. If PN can be measured by means of remote sensing trends in PN emissions of the petrol fleet could be monitored over time to keep an eye on future increase of GPF related PN-emissions.

Petrol NO_x-test method and applicability

The proposal does not contain a procedure for measurement nor a limit value for NO_x-emissions. Both need to be specified. Real-world NO_x-emissions of petrol vehicles as well as the potential impact of high emitters on the total emissions of the petrol fleet have been investigated in great quantity [4] [5] [6]. With properly functioning aftertreatment systems petrol vehicles are capable of emitting low NO_x-emissions, relying predominantly on the three-way catalyst.

[2] https://cordis.europa.eu/project/id/814951

However, when components deteriorate, break down, or are tampered with real-world emissions can drastically increase. The relationship between real-world NO_x-emissions and test results under PTI testing conditions is weak. Measurements of NO_x-emissions under unloaded idling conditions similar to the traditional gaseous emissions test, showed weak correlation with on-road emissions levels, suggesting a possible need for testing under engine load.

The proposal limits the applicability of the NO_x-testing method for petrol vehicles to Euro 6d-TEMP and newer, thereby excluding a significant share of petrol vehicles equipped with a three-way catalyst and capable of low NO_x-emissions. According to PBL data [7] representing the Dutch vehicle fleet, in 2030 vehicles with an emissions class older than Euro 6d-temp are expected to represent more than 60% of the petrol fleet of passenger cars in the Netherlands, for more details see Appendix A. Not only is this an important share of vehicles that can contribute significantly to the petrol fleet emissions, when NO_x-emissions rise this will remain invisible in the applicable testing methods. Regular gaseous emissions testing for petrol vehicles is unable to effectively detect on-road high NO_x-emitters as of today [8]. Therefore, it is recommended to consider improving the existing testing methods for petrol vehicles introduced before Euro 6d-TEMP, or a new NO_x-test should also be introduced for pre-Euro 6d-TEMP vehicles. Small improvements that can be taken into account for the traditional gaseous emissions test are tightening the lambda window and prescribing a stricter preconditioning methodology. The latter removing the opportunity to unrealistically elevate catalyst temperatures and doing so temporarily improving emission reduction of the catalyst and pass the test.

OBD test

In the current framework OBD testing is either performed to substitute gaseous emissions testing or vice versa. In the proposal OBD testing is relocated to complement visual inspection, allowing for improved detection of deterioration, malfunction or manipulation of aftertreatment systems.

OBD of recent generations of vehicles is very advanced and is capable of detecting emissions related malfunctions and provides a lot of useful information about the technical status of engines and emission control systems. To be able to complete an OBD test, an absence of fault codes as well as the 'readiness' status is required. Readiness means that all diagnostic tests are successfully completed and no faults are detected. After a repair, a reset of fault codes is necessary. This means that all diagnostics tests need to be run and 'readiness' is only reached when these tests are successfully completed without new fault codes. For some diagnostic functions, a certain amount of driving with the vehicle is necessary. It is therefore not possible to do an OBD check immediately after a repair has taken place and thus the repaired vehicle can't immediately pass the OBD test to be declared roadworthy.

OBD testing can be a useful test item for road side inspection, to assist in detection of malfunction or tampering. In most cases the OBD will have the readiness status and is able to report on emissions related fault codes in the vehicle.

Visual checks

A visual check can strengthen the methods of testing as it is easy to identify not-approved parts such as 'race catalysts', e.g. the European type approval stamp E-number needs to be present on OEM and replacement catalysts. Absence of components due to removal can be identified with the help of official drawings of the exhaust lay out.

3.2 PTI interval

In the current EU methodology, all M1 and N1 vehicles are subjected to PTI every two years from a vehicle age of four years old. The Netherlands however is already significantly more stringent and differentiates between petrol and diesel vehicles. Petrol passenger cars are subjected to PTI every two years from a vehicle age of four years old and every year from eight years old, whereas diesel passenger cars are subjected to PTI every year from a vehicle age of three years old. Diesel vans are inspected for the first time after three years, and then annually thereafter. Petrol vans are inspected for the first time after four years, then twice every two years, and then annually from the eighth year onwards.

The new EU proposal increases the PTI interval with yearly inspections from 10 years after vehicle registration, thereby closing the gap between EU and NL largely, but not entirely. Additionally the EU proposal adds yearly exhaust emissions testing for N1 vehicles in the first 3 years after vehicle registration. However, it is not useful to perform an annual emissions test on N1 vehicles, which are mainly diesels. Typically, vehicle emissions tend to increase with age and mileage, and problems with particulate filters and SCR catalysts are not expected in the first three years. Additional efforts to reveal deterioration and malfunctions perform best when targeting older vehicles, not the newest ones up to three years old. This is further substantiated with the NO_x-emissions of vans measured using plume chasing shown in Figure 3.1 and the PN PTI results for vans shown in Figure 3.2, both obtained in the Netherlands. The first figure shows that average NO_x-emissions of vans up to four years old remain steady and low, with very little scatter. Beyond this age both the average value and the scatter increases. The second figure shows the PN PTI tests conducted in the Netherlands during the first two and a half years after introduction of the test. The figure shows the number of rejected vehicles by age and the number of PN tests performed. During this time period, 1,6 million vans were tested, of which 63 thousand vans failed the PN test. The highest number of rejections occurred for vans older than 8 years approximately and very few rejections occurred for the newest tested vans from 2022 and 2023. Additionally, although the amount of vehicles tested with a first registration before 2018 decrease with increasing age, the amount of rejections actually increase with increasing age, down to 2011.

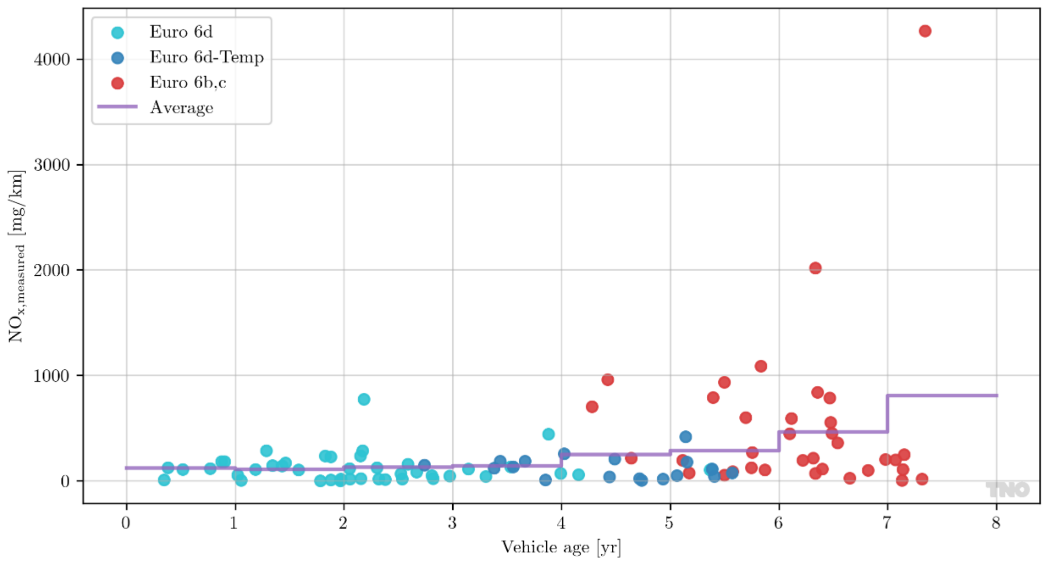

Figure 3.1: NO_x-emissions of N1 vehicles plotted against the vehicle age, measured by the TNO Plume Chaser in the Netherlands.

Detailtabel tellerstanden

Aantal meldingen	Aantal Deeltjestellingen	Aantal misser	Aantal gebrek	Aantal uitbouw
2216450	1631208	554	50825	11806

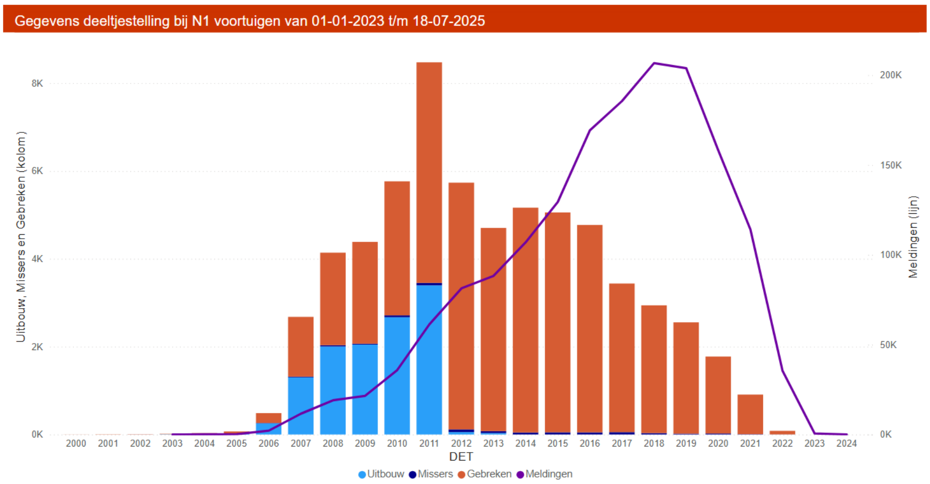

Figure 3.2: Number of rejection of vans in the PTI on the particle test for checking the particulate filter plotted against the vehicle age. The line shows the number of PTIs performed.

4 Fleet emissions screening emissions verification and RSI

In this chapter fleet screening for high emitters, remote sensing techniques, emissions verification testing, and the implications and recommendations for Roadside Inspection RSI are discussed.

What is required for emission screening, high emitter detection, and verification?

- In the new proposal is stated that at least 30% of the registered motor vehicles has to be screened annually in a member state.
- This comprises passenger cars, vans, heavy commercial vehicles, busses and motorcycles.
- A total number of about 11 million vehicles are registered in these categories in the Netherlands, see Appendix A for more details, and therefore at least 3,4 million individual vehicles need to be screened annually.
- The goal is to identify vehicles suspected of high emissions.
- High emitters are defined as vehicles with pollutant (and sound) emissions above a certain level.
- The level is defined as double the amount of the average of the fleet for similar vehicles, i.e. from the same category, emissions standard and ignition type (positive and compression).
- At least three consecutive measurements within 6 months are needed to define whether or not a vehicle is a potential high emitter. Member States may choose to only conduct one or two measurements.
- The vehicle selection framework will likely work as a deterrent for a share of vehicle owners that would have otherwise chosen to manipulate their vehicle.

4.1 Remote sensing equipment

The proposal includes two definitions for the screening technology: remote sensing and plume chasing. Remote sensing for road traffic emissions is the overarching term for measuring emissions without being directly connected to the source. There are two variants for exhaust emissions: point sampling, for which exhaust gas plumes are measured along or above a road at fixed locations, and plume chasing, for which a measurement car driving on the road samples the plumes of the vehicle in front.

For **point sampling**, measurement equipment is placed in a (semi) fixed position near traffic, next to or above the road.

There are two market-ready systems:

1. HEAT EDAR[3], overhead, placed above traffic (bridges, truss, poles, gantry)
2. OPUS RSE[4], cross-road, placed next to traffic

For **plume chasing**, measurement equipment is placed on-board of a measurement vehicle, with which traffic is chased and emissions are measured in the plume of the chased vehicle.

When looking for market-ready systems one is found:

- Airyx Plume Chasing[5]

As point sampling and plume chasing differ in their approach, so do their respective advantages and disadvantages. With point sampling the momentary concentration of pollutant emissions of a vehicle is measured when the vehicle passes the remote sensing location. With plume chasing the emission concentrations from the plume are measured when driving behind a vehicle for several minutes. A difference between the two methods is the productivity rate. The advantage of point sampling method is the ability to measure large numbers of vehicles, hundreds an hour (the number depending on traffic intensity, location and some loss due to invalidated measurements), whereas the productivity of plume chasing is much lower, with typically 12 valid measurements an hour.

An advantage of plume chasing is the ability to estimate the emissions level of vehicles more accurately than point sampling due to the extended timeframe per vehicle measurement. Single passes can show high emissions which are temporal and approved, such as during a particle filter regeneration. The use of multiple vehicle passes improves accuracy, which is important for high emitter detection. For point sampling very specific requirements need to be met for high-emitter detection to increase reliability. Research[6] mentions that acceleration of the measured vehicle is required, or a slight road inclination also improves the reliability. When point sampling is used for high emitter detection, drivers may lift throttle in anticipation leading to reduced or zero emissions at the time the vehicle passes, hereby preventing a valid measurement. Measurements performed exclusively by point sampling could thereby be exploited by drivers to avoid selection for an emissions test at the road side or a PTI station.

Limited equipment suppliers

At the time of writing there is a very limited number of suppliers for remote sensing measurement equipment: within this work only three systems have been found. As the proposal requires each European member state to perform screening on a significant share of their national fleet, this will induce significant demand for remote sensing equipment. This demand needs to be met with sufficient supply and preferably sufficient variety in suppliers for remote sensing equipment to prevent a vendor lock-in. It is therefore important that the proposal includes a review of the current (and potential) availability of remote sensing equipment suppliers and their respective supply capacity.

Need for standardisation and certification

According to the proposal remote sensing measurements must be collected across various locations—both within the vehicle's country of registration and in other member states.

[3] https://www.heatremotesensing.com/edar
[4] https://opusrse.com/
[5] https://airyx.de/item/real-driving-emissions/
[6] *Final guidance document on how to apply remote emission sensing for policy relevant applications*, Deliverable D4.2 of the CARES project, June 2023. https://cares-project.eu

This requires measurement results to be comparable, independent of measurement equipment, location and weather conditions. Also if results are to be used for selection for verification testing, the remote sensing methods must be equally selective. Achieving this comparability requires standardized and certified measurement equipment. Certification should define acceptable tolerances and approved measurement conditions. In addition, standardized measurement procedures are essential to ensure reproducibility and accuracy across different setups. The certification process by a notified body can be similar to the one for particle counter measurement equipment used for PN-PTI for diesel vehicles, already in force in several member states.

Standardization and certification of both remote sensing equipment and measurement procedures are instrumental in the success of the fleet screening approach and need to be included in the proposal.

Measurement of particle number emissions

For fleet screening particle emissions are an important factor. Modern diesel and petrol vehicles are equipped with particle filters to reduce the particle mass (PM) and the particle number (PN) emissions. A properly functioning particle filter effectively reduces particle emissions, but even a small crack in the filter will significantly increase PN emissions, often without obvious insight to the driver or owner. Larger defects or removal of the particle filter will further increase the particle emissions of a vehicle.

For identifying vehicles in the fleet with high particle number emissions remote sensing technology could be a valuable method. The remote measurement of NO_x is mostly covered by all three available remote sensing systems, however measurement of particle number emissions is not. Current market-ready plume chase equipment does not include measurement of particle emissions, although both point sampling systems do. The OPUS RSE system is able to measure particle emissions expressed as smoke factor (opacity), similar to PTI testing of older diesel vehicles which is not suited for modern diesels. The HEAT EDAR system measures particulate matter emissions and is able to express the measured quantity in a unit using ‘particle number’. Further development of remote sensing particle emission techniques is necessary to provide proper high emitter detection during fleet screening.

4.2 Fleet screening and vehicle selection

Although plume chasing is most favourable from the perspective of measurement result certainty, it would be a significant challenge to perform fleet screening solely with plume chasing given the Dutch target of 3.4 million vehicles yearly.

To illustrate, given:
- 12 vehicle measurements per hour with a plume chaser [9]
- Assuming 8 hours per day, 260 workdays per year results in 24,960 measurements per year per plume chase vehicle

This would require 137 plume chase vehicles to reach the yearly Dutch screening target in 2025.

Point sampling is capable of measuring larger numbers of vehicles.

To illustrate, given:

- 70,000 vehicles per day, 365 days per year[7]

Results in:

- 25.6 million measurements per year per point sampling system

It is important to note here that the amount of emission measurements can be predicted directly from location and traffic flow, but the number of unique measurements each year cannot. If the point sampling system is fixed in one location for the entire year, there will be a larger share of recurring vehicles among the measurements, for example from commuters. Recurring vehicles will decrease the share of unique measurements counting towards the yearly fleet screening target. Taking into consideration periodical relocation of point sampling equipment will facilitate in decreasing the share of recurring vehicles in the measurements. An indication of the share of recurring vehicles in one location can be drawn from literature, where over a period of two weeks less than 60% of measurements were from recurring vehicles [10]. To estimate the required point sampling systems, various scenarios for the share of recurring vehicles in the measurements have been calculated. The results are shown in Table 4.1.

Table 4.1: Estimation of the required Remote Sensing (RS) systems needed for reaching the 3.4 million target in the Netherlands, using various shares of recurring vehicles among the measurements.

Recurring vehicles	**60**	**80**	**90**	**95**	**98**	**%**
Unique vehicles per year	10,220,000	5,110,000	2,555,000	1,277,500	511,000	**vehicles**
Required R.S. systems	0.3	0.7	1.3	2.7	6.7	**systems**
Rounded up	*1*	*1*	*2*	*3*	*7*	***systems***

The results from the table estimate that dependent on the share of recurring vehicles within the measurements there is a need for between 1 and 7 remote sensing systems to reach the yearly screening target in 2025. In this estimation one system is expected to measure all lanes in one direction of a given measurement location. Depending on the technology, multiple systems per location might be needed.

Combine plume chasing and point sampling

Using a strategic combination of point sampling and plume chasing could allow for more efficiently reaching the targets than with just one methodology. Choosing the approach of combining plume chasing and point sampling allows for measuring large numbers of vehicles with point sampling and enhancing the overall measurement accuracy with plume chase measurements. Vehicles suspected of high emission, for example based on point sampling measurements, can be included in the vehicle selection criteria for the plume chasing measurements. Additionally, point sampling is restricted to high vehicle flow roads and is limited in its flexibility to change measurement location, whereas plume chasing can be performed on any road with sufficient vehicle speed and for any duration of time (high flexibility). Point sampling locations can more effectively be recognized and (structurally) avoided by drivers than plume chasing. However, point sampling can also be implemented in low speed conditions such as urban roads, which plume chase is not suited for.

This allows for multiple measurements of the same vehicle within one day thereby reaching the minimum of three datapoints per vehicle quicker, as well as providing measurements under slightly varying conditions from road, traffic and engine temperature, instead of measurements that are only separated in time when using a single point sampling system on one road and measuring one vehicle on multiple occasions.

[7] https://dexter.ndw.nu/opendata - Traffic on the A4, A12 and A13 motorways in 2024

Remote sensing as source for average emission levels

Based on the data from the fleet screening, vehicles shall be selected for a follow-up exhaust emissions verification. The proposal states a selection criterium of more than double the average emissions levels for vehicles belonging to the same vehicle category, emission class and ignition type, with selection based on at least three measurements within a period of six months. In the current proposal there is no clear definition of the intended source for the average emission levels.

A logical methodology for the average emission levels would be to determine these using remote sensing data from fleet screening. This would ensure emission levels are established under representative conditions, if needed it can allow for adjusting average emissions levels according to location conditions, and it allows for periodically updating the average emission levels in accordance with fleet changes over time. Remote sensing exhaust emissions measurements, point sampling especially, are expected to be significantly influenced by location conditions, e.g. a downhill driving location will demand a very different driving conditions than uphill driving, thereby influencing the average emission level. Additionally, with constant modernisation of the vehicles in the fleet and continuous reduction in the share and impact of high emitter vehicles due to the measures such as the roadworthiness package it is necessary to continuously update the average emission levels.

Share of fleet selected for verification

The proposed threshold level for vehicle selection is two times the average emissions level. Using a recent study [9] the expected implications for the Dutch fleet can be substantiated. In the plume chase measurement results for NO_x the amount of vehicles above the proposed threshold are 7% for LDV diesel, 8% for LDV petrol and 9.5% for HDV diesel. For simplicity, an average of 8% is assumed for the share of screened vehicles that will be selected for follow-up exhaust emissions verification.

To illustrate, given:

- 3.4 million vehicles screened (based on the 30% target)
- 8% of screened vehicles selected for follow-up

Results in:

- 272,000 vehicles selected for follow-up per year

Alternatively, the vehicle selection threshold could also be implemented in a staged approach. Initially the threshold could be less strict than a factor of 2, or even simply a numerus fixus for vehicle selection could be set using only the highest measured emissions from remote sensing. This will allow a more controlled, soft start-up of the follow-up system and limit the chance of overloading the back office early on. Additionally this allows for evaluating the implemented system in the real-world before it is running on full speed, for example on the share of vehicles selected by screening as potential high emitters that pass verification testing with low emissions.

In the second stage the threshold is tightened to the proposed factor of 2, or the numerus fixus is lifted. Additionally, a minimum absolute threshold value could be implemented for the future scenario where the average emissions are so low in value that the factor 2 threshold criteria results in the inclusion of low emitting vehicles. With a minimum absolute value for the threshold, these low emitting vehicles are excluded from selection.

4.3 Effective verification

In order to obtain the full potential from the proposed updated RWP, vehicle selection from remote sensing and verification testing need to be (cost-) effective and targeting high emitters only.

A key element in the effectiveness is the harmonization of the remote sensing techniques with the high emitter selection criteria and the verification testing methods. When remote sensing is used for selecting vehicles suspected of high emissions, the measurement should be able to detect high emitters that would fail the methods of testing during verification.

High emissions measurement results will have consequences for vehicle owners as inspection will take place either immediately on the roadside or within 15 days in a PTI test centre, and therefore vehicle emissions estimation during screening requires high certainty. It is of great importance to prevent selection of non-high emitter vehicles, i.e. wrongly notifying a vehicle owner of significantly elevated emissions, requiring a follow-up within a short time and then approving the vehicle with low emissions during said follow-up. In addition, it is also important to prevent selection of high emitter vehicles that go undetected during follow-up testing, i.e. correctly recognizing high emissions during screening and then being unable to verify high emissions with the available methods of testing. Preventing this will improve efficiency in detecting high emitters in the fleet and repairing or removing them, as well as promote trust in the system from vehicle owners.

In case of suspected high emissions from remote sensing, framework conditions should be:
- Fleet emissions screening and verification testing measure the same parameter, preferably under similar conditions.
- The high emitter selection threshold is less stringent than the verification threshold.
- Lead time between the last remote sensing measurement and verification testing is limited.

In case of high NO_x-emissions during remote sensing, this means that verification testing is also performed using a NO_x-test method. Continuing the example, the less stringent NO_x-threshold for selection, e.g. 100 mg/km, will ensure that the more stringent threshold, e.g. 60 mg/km, is (almost) always met when the vehicle is subjected to verification testing. Lastly, by limiting the lead time between the last remote sensing measurement and verification testing the possibilities are also limited for making changes to the vehicle that affect the emissions. Especially in case of tampering this time window will allow drivers to restore the vehicle to its original low emitting condition before arriving at the verification testing facility.

NO_x-emissions verification testing of petrol vehicles

As mentioned in an earlier chapter, the proposed testing methods for petrol vehicles now includes one for NO_x-emissions, although it is limited to vehicles with emissions class Euro 6d-temp and newer. Not only does excluding older vehicles result in reduced detection of NO_x-high emitters in the PTI, it will also affect verification testing. Remote sensing will be able to detect high NO_x-emissions from modern vehicles with an emissions class up to Euro 6d-temp, these high emitters will then be selected, but ultimately cannot be tested on their NO_x-emissions during verification testing. As these modern vehicles are estimated to still have a significant share in the Dutch petrol fleet in future years (e.g. 2030), and are known to have NO_x-high emitters among them, adequate verification testing methods are needed that include older emissions classes than Euro 6d-temp.

Overall result for verification testing

In summary, in the RWP is proposed that the following verification tests should be performed:

- For all cars (if equipped with OBD) the OBD must be read.
- For petrol cars, the gaseous emissions test must be performed as the verification test. Additionally for petrol cars from Euro 6c, the new PN test must be performed, and for petrol cars from Euro 6d, a new PTI NOx-test for petrol must be performed. This
NO_x-test still needs to be fully developed as it is undefined in the proposal.
- For diesel cars up to and including Euro 5a/Euro V, the opacity test must be performed as a verification test. Additionally for diesel cars from Euro 5b/Euro VI, the new PN test must be performed instead of the opacity test, and for diesel cars from Euro 6d/Euro VI, the new hot idle NO_x-test must be performed. Thus, for diesel cars up to and including Euro 6c/Euro V, there is no NO_x-verification test.

For a relatively large number of cars, only the gaseous emissions test or the opacity test must be performed. These are older tests for which only modern vehicles with very high emissions will fail. Given the relatively low vehicle selection threshold of two times the average emissions of similar vehicles, there is a real risk that vehicles from these categories with high emissions during remote sensing will simply pass verification testing with low emissions. With an expected amount of selected vehicles of around 272,000 and a significant share of vehicles in the fleet that can only be subjected to the older test methods, it is expected that a large number of these 272,000 selected vehicles will go to verification testing for nothing.

Alternative approach for verification testing

Alternatively, verification testing methods could be separated from the methods of testing for PTI and RSI. The conditions of the PTI significantly constrict the boundary conditions that the methods of testing have to adhere to. PTI tests need to be simple, quick and affordable as the majority of the fleet has to take them either every two years or every year. By using remote sensing to reveal the small share of (suspected) high emitters among the fleet, verification testing requirements could be reevaluated. The time and resources available for reducing high emitters in the fleet only needs to cover a small subset of the entire fleet of vehicles, resulting in more per suspected vehicle. Verification testing could be performed in a more thorough manner and under realistic conditions, thereby increasing the accuracy of verification testing. Aftertreatment systems of modern vehicles are designed for driving in the lab and on the road, not for idling at a garage, and therefore the best approach for accurate verification testing is by performing tests close to driving conditions. Examples of alternative methods for verification testing are thorough visual inspection with a focus on approved parts, testing under load on some form of chassis dyno, driven testing with mobile emission measurement equipment connected to the vehicle exhaust, or even simply plume chasing in a controlled environment (e.g. a test track).

4.4 Cost implications

The costs for plume chasing and point sampling campaigns can be estimated. Costs are associated with equipment and operation, this includes purchase, maintenance and repairs, logistics, training, personnel, processing of results, administration and IT infrastructure.

Below are some rough first estimates, for a fully accurate and complete estimation of the total cost more detailed calculations are needed.

Remote sensing

For **point sampling**, an estimation can be made from literature [11]. In a two to three week campaign the overall cost was €120k to measure 200k vehicles with two sensors, leading to an average cost of €0.60 per vehicle. Extrapolation of these numbers to an entire year (3.4 to 5.2 million measurements) would lead to a cost between €2 to 3 million per year. A commercial supplier of remote sensing equipment and services mentioned that when campaigns are more structural and last longer, costs per vehicle can come down significantly compared to campaigns of just a few weeks. Fixed costs can be spread over more vehicles and benefits come from the increased scale. The supplier estimated that cost can become approximately €0.20 to €0.30 per vehicle.

Another remote sensing supplier made an example calculation for the Netherlands for the remote sensing of 30% of the fleet (3 million vehicles) annually and took account of: (24 Remote sensing devices), CAPEX (€2.5 million, including initial investment in equipment IT platform, infrastructure, verifications), OPEX (€3.7 million/year, maintenance and operation costs for government including spare parts, repairs, labour, high emitter detection, IT platform), revenues from fines (€1.8 million/year) and indirect savings form AQ improvement (€5 million/year) and calculates based on these figures a price of €1.2 per vehicle.

For **plume chasing,** the equipment consists of instruments, a vehicle, personnel maintenance, repairs. The estimation is €100k per vehicle to purchase (every three years). Additionally, when there is a single team of two people performing year round plume chasing measurements (€100k per person), yearly vehicle and equipment maintenance (incl. calibration) (€20k), running cost such as fuel (€15k), and incidental repairs. This estimation would lead to €468k per year per plume chase vehicle for 260 working days.

The remote sensing presentation of 17 June 2025 by the EC includes several rates for remote sensing. The estimate for plume chasing of €32.5k only covers capital costs, most likely only the equipment, and does not include vehicle (running) costs and man hours. For remote sensing the capital cost is estimated at €85k, maintenance at €4.25k annually, and processing and data management €24k annually. Even with a full replacement of the system each year these estimates are at least many times lower than estimates from remote sensing suppliers.

Implications for selected vehicle owners

For the economic cost implication of follow-up testing of selected vehicles, the following assumptions are considered:

- Vehicle owners have to spend two hours, at €50 per hour
- Follow-up testing costs €50

This leads to an estimated total cost of €150 per selected vehicle. With 272,000 vehicles selected per year, this costs selected vehicle owners €40.8 million per year to perform follow-up testing on all selected vehicles.

This does not yet include any cost for repairs or additional testing in case the vehicle fails follow-up testing and is deemed not roadworthy.

4.5 RSI

The RWP proposal extends the scope of road-side inspections from lorries with N1 vans, and defines national annual target of 5% and 2% of the fleet registered for lorries and vans respectively. Roadside inspection targets were formerly on a European level, but are now proposed to be achieved on a national level.

Using national fleet data from 2025 on vehicle registrations the target amounts can be calculated.

Registered vehicles in the Netherlands, more details in Appendix A:
- 215,000 HDV
- 1,050,000 LCV

Given the targets of 5% and 2% for HDV and LDV respectively, this would result in:
- 10,800 HDV to be subjected to roadside inspection yearly
- 21,000 LCV to be subjected to roadside inspection yearly

Remote sensing as selection tool for effective road side inspection

The proposal contains multiple options for selecting vehicles for roadside inspection, among which is remote sensing. Using remote sensing results, in particular from Plume Chasing, as a basis for RSI selection has shown to significantly increase the success rate of finding high emitting vehicles [11]. RSI efforts should be aimed at suspicious vehicles and with Plume Chasing suspicions of high emissions can be confirmed or rejected by simply driving behind the vehicle in question. Therefore in the context of emissions, the RSI targets should include Plume Chase measurements with low emission results to count as initial inspections. This allows for more targeted detailed roadside inspection of vehicles suspected of high emissions and minimizes unnecessary stops of properly functioning vehicles.

Hot idle NO_x -test for verification

The diesel NO_x-testing method is designed for detecting full SCR deactivation and tampering, and has shown to require a warm-up drive and large dependence on sufficient aftertreatment temperature. The purpose of the testing method and the required conditions align well with RSI and the test should be combined with Plume Chasing for effective selection of NO_x-high emitters followed by immediate roadside verification with the testing method. In this way, the requirements of getting the aftertreatment system up to temperature for the test and maintaining it during are easily met. Additionally, detecting deactivated SCR systems, either broken or manipulated, is one of the important purposes of RSI.

5 Conclusions

The current framework for Periodical Technical Inspection (PTI) and Roadside Inspection (RSI) is outdated and ineffective for modern vehicles equipped with advanced emission reduction systems. To protect the environment we live in today and in the future, new elements are needed to detect high emitters and to enforce repair or removal from the fleet. The RWP proposal includes new elements regarding remote sensing of on-road vehicle emissions, selection criteria for verification testing, and additional and improved emission testing methods designed for modern vehicles. In the proposed updated framework there is increased attention on aftertreatment durability and real-world emissions, similar to the type approval improvements such as RDE and ISC which have shown their success.

In order to obtain the full potential from the proposed updated RWP, vehicle selection from remote sensing and verification testing need to be (cost-) effective and targeting high emitters only. Furthermore, the feasibility of new test methods should also be carefully examined under the practical conditions under which the PTI is performed in many Member States. A key element in the effectiveness is the harmonization of the remote sensing techniques with the selection criteria for potential high emitters and the verification testing methods. Vehicle selection should target the small share of vehicles with the highest emissions often responsible for a significant share in the total fleet emissions. Lead time between vehicle selection and verification testing should be minimized to tackle tampering, and there should be avoided that selected vehicles suspected of high emissions fail to show high emissions results during verification testing.

The proposed testing methods for NO_x only apply to relatively new vehicles with emissions class Euro 6d-temp and newer, even though vehicles up to that emissions class also possess advanced aftertreatment systems that can deteriorate, break or be tampered with leading to high emissions. Current testing methods, that is reading of the OBD and the four-gas emissions test for petrol cars, are unable to identify NO_x-high emitters and therefore this approach poses a real risk of identifying a large share of potential high emitters with an emissions class up to Euro 6d-temp that will simply pass the available testing methods during verification. This is an undesirable situation and will lead to a lot of resistance from vehicle owners that are expected for verification testing on short notice and then pass all testing.

In the current proposal a new testing method of NO_x-emissions of petrol vehicles is included, but it has not yet been defined and is limited to vehicles with emissions class Euro 6d-temp and newer. Creating a quick and effective stationary petrol NO_x-test is expected to be challenging. More importantly, high NO_x-emissions by modern petrol vehicles with emissions class up to Euro 6d-temp cannot be verified with a test under low idle, no-load conditions such as the currently available and ineffective gaseous emissions test. So the proposal lacks a dedicated NO_x-verification testing method for these vehicles. A new NO_x-test should also be introduced for pre-Euro 6d-temp vehicles. High emitters are prevalent among this vehicle category and have been shown to contribute significantly to the total fleet NO_x-emissions.

Also a new NO_x-testing method has been defined for diesel vehicles with emissions class Euro 6d-temp and newer. It looks like high NO_x-emissions of modern diesel vehicles equipped with an SCR with emissions class up to Euro 6d-temp can be well determined with the new test.

However, the NO_x-testing method is mainly designed for detecting full SCR deactivation and tampering (not deterioration), and has shown to require a warm-up drive and to have a large dependence on sufficient aftertreatment temperature. For a hot catalyst, the test needs to be done immediately after arrival at the PTI station. If the SCR catalyst has already cooled down when starting the PTI, a warm-up drive outside the PTI station needs to be done. These conditions align very poorly with the way the PTI is done in many Member States. However, the new NO_x test for diesel aligns well with RSI and could be combined with Plume Chasing for effective initial inspection of NO_x-emissions followed immediately by a more detailed roadside verification with this test method.

The RWP introduces a new national target for RSIs for light commercial vehicles (LCV), in addition to the already existing RSI target for heavy duty vehicles (HDV). Since the new NO_x-test for diesel is difficult to implement within PTI due to the required hot catalyst, it is obvious to introduce checking of NO_x-emissions of diesel within the RSI. For this, the RSI targets for LCV and HDV should include Plume Chase measurements, and not just be limited to stopping vehicles at the roadside. Every plume chasing measurement should count as an initial roadside inspection for the RSI target. RSI efforts should be aimed at suspicious vehicles and Plume Chasing allows the emissions of a vehicle to be checked without the need for stopping the vehicle. Based on the outcome of this initial inspection, the inspector can decide whether the vehicle be stopped and be subject to a more detailed roadside inspection in which emissions are measured with a NO_x-test.

Particle Number (PN) testing is included in the proposal for petrol and diesel vehicles.
The PN testing method for diesel has already been in force in multiple EU member states and has shown successful results in detecting defective and removed particle filters. The proposal includes a limit value of 250.000 #/cm^3 which is in line with the original technical recommendations and slightly tighter than the current limit value in the Netherlands.
For petrol vehicles PN testing has not yet been enforced in any of the member states. The main challenge for this test is defining limit values, as the difference in particle emissions of a vehicle with and without a particle filter is much less evident for petrol vehicles compared to diesel.

Recommendations

The proposal addresses many relevant topics, but still leaves a number of matters unresolved.

To further strengthen the effectiveness and efficiency of the RWP, TNO has the following recommendations:

- Improve NO_x- and PN-testing methods:
  - Develop a robust NO_x test for petrol vehicles that includes engine load conditions, as idle-based tests show weak correlation with real-world NO_x-emissions.
  - Include NO_x testing for pre-Euro 6d-TEMP vehicles.
  - Finalize PN test method for petrol vehicles and establish a reliable limit value to avoid false positives and negatives.
- Strengthen the remote sensing framework:
  - Standardize and certify remote sensing equipment and procedures.
  - Expand capability to measure particle emissions.
  - Validate cost estimates and use a mix of point sampling and plume chasing for efficiency.

- Enhance fleet screening:
  - Use fleet screening data to set thresholds.
  - Introduce a minimum absolute threshold and apply a staged approach for verification testing.
- Ensure harmonization of the remote sensing techniques with the selection criteria for potential high emitters and the verification testing methods. It is of great importance to prevent selection of non-high emitters and selection of high emitters that go undetected during verification testing.
  - Fleet emissions screening and verification testing measure the same parameter, preferably under similar conditions.
  - The high emitter selection threshold is less stringent than the verification threshold.
  - Lead time between the last remote sensing measurement and verification testing is limited.
- Align verification testing with real driving conditions: separate verification testing methods from PTI and RSI constraints by exploring alternative methods such as chassis dyno, on-road testing, and controlled environment plume chasing.
- Integrate plume chasing into RSI for targeted inspections, count every plume chase measurement as an initial inspection, and combine it with diesel hot-idle NO_x-testing.

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Signature

TNO ⟩ Mobility & Built Environment ⟩ Den Haag, 4 November 2025

ValidSigned by Jan Hoegee on 2025-11-05 09:09:06	ValidSigned by Quinn Vroom on 2025-11-05 07:24:16
Jan Hoegee Research manager	Quinn Vroom Author

Appendix A
Details of the fleet in the Netherlands, 2025 and 2030

Table A.1: Data on Dutch motor vehicles registrations per category and age, source: opendata.cbs.nl

Age category	LDV (car) Count	LCV (van) Count	HDV (truck, bus) Count	L-cat (motorcycle) Count	*Total*
Total	*9,247,810*	*1,050,688*	*215,204*	*720,591*	*11,234,293*
younger than 1 year	377,211	115,336	18,436	18,234	*529,217*
1 and 2 years	785,442	129,410	28,978	33,460	*977,290*
3 or 4 years	896,571	131,554	22,733	35,185	*1,086,043*
5 or 6 years	1,031,271	152,746	31,333	36,310	*1,251,660*
7 or 8 years	927,256	131,559	24,144	37,688	*1,120,647*
9 to 12 years	1,283,035	125,076	18,611	48,342	*1,475,064*
12 to 15 years	1,390,642	93,567	10,899	47,122	*1,542,230*
15 to 20 years	1,525,750	101,900	15,430	108,024	*1,751,104*
20 to 25 years	635,647	38,609	13,284	97,729	*785,269*
25 years and older	394,985	30,931	31,356	258,497	*715,769*

Table A.2: PBL data on the share of vehicles with an emission class older than Euro 6d-temp (<2020) in the fleet for the Netherlands in 2025 and 2030 (prognosis).

Passenger cars	**2025**		**2030**		
	Petrol	Diesel	Petrol	Diesel	
Total	8100	700	7600	300	thousand vehicles
<2020	6400	700	4800	300	thousand vehicles
Rel. share	**79%**	95%	**63%**	91%	thousand vehicles

Appendix B
Additional details to proposed changes to the RWP

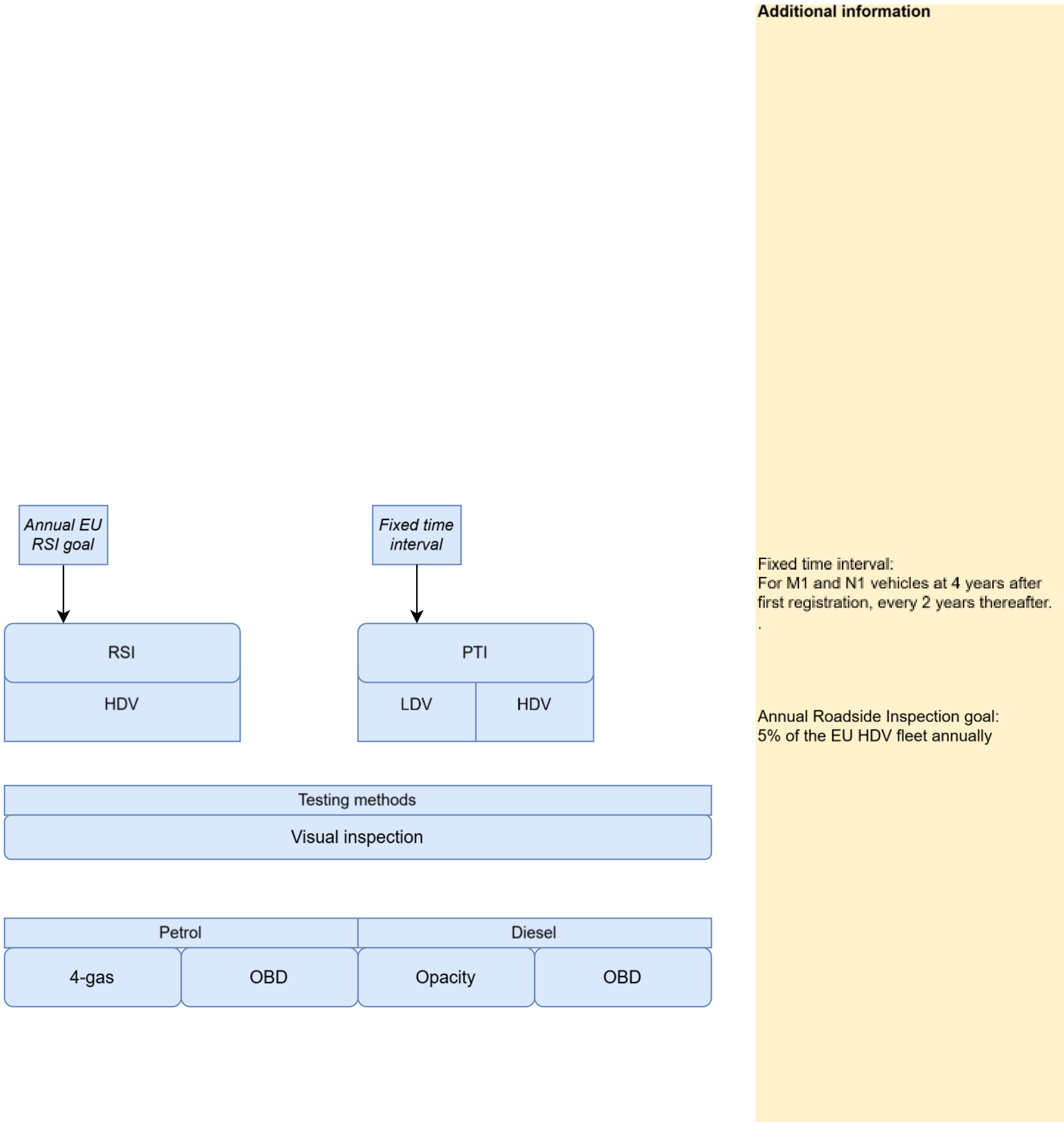

Figure B.1: Schematic overview of the current situation for RSI and PTI.

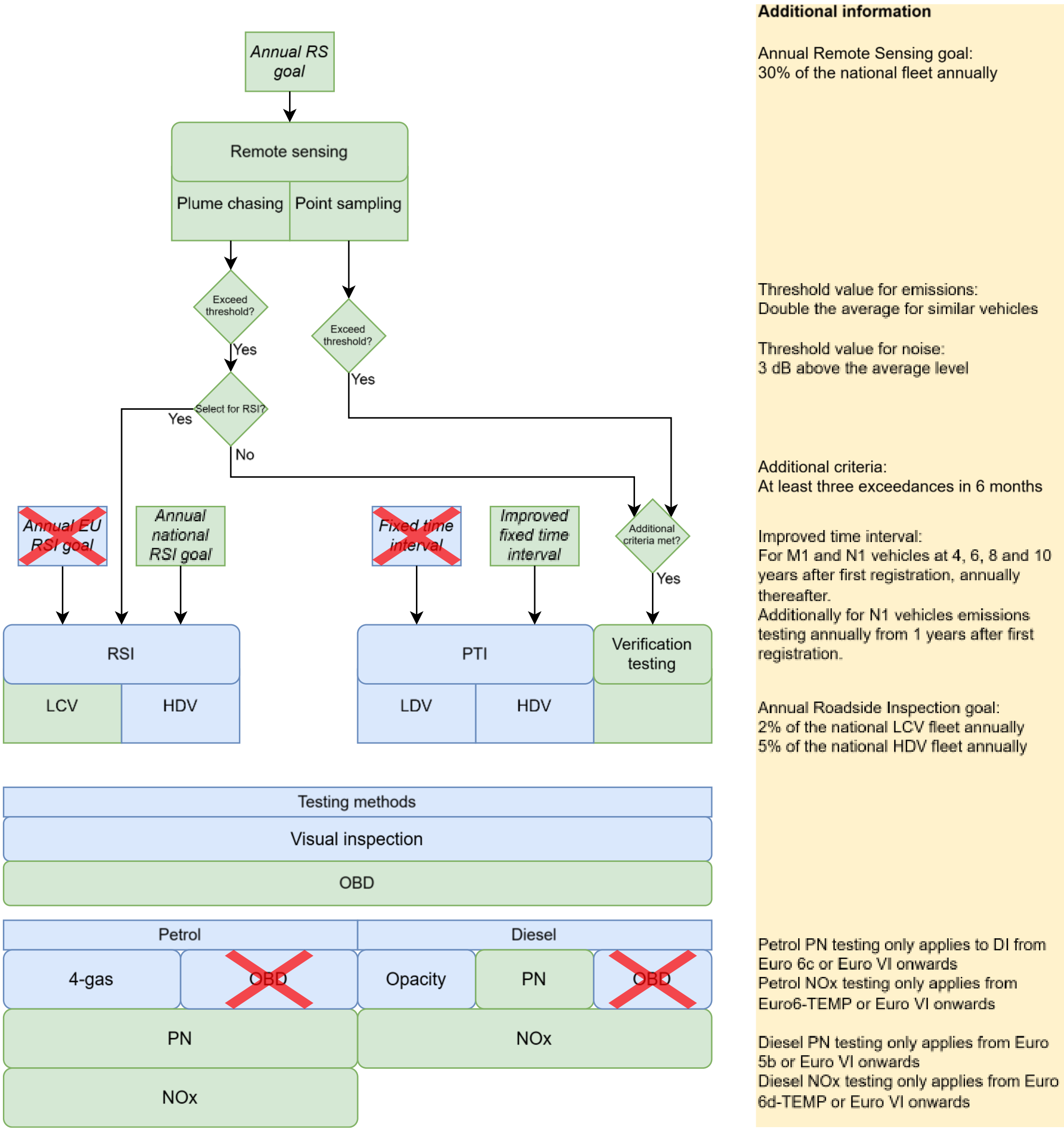

Figure B.2: Schematic overview of the proposed updated situation for RSI and PTI.

Table B.1: Overview of proposed changes relevant for exhaust gas emissions.

Current	Proposed changes
Scope Lcat (motorcycles, 3 and 4 wheelers) >125 cm^3 option alternative measures	+ Lcat (motorcycles, 3 and 4 wheelers) remove opt out + Mandatory PTI after altering or modifying components.
Periodic Technical Inspection (PTI) PTI intervals: EU M1, N1 (cars and vans): at least 4-2- NL 4-2-2-1- for petrol cars vans and ev's NL 3-1-for diesel and LPG cars and vans	M1 4-2-2-2-1- + Annual emissions PTI for N1 (vans)
	+ presence of not authorized (OEM or homologated) electronic devices (e.g. manipulation device like an AdBlue emulator) not allowed + OBM as alternative
M2, M3, N2, N3, O3 and O4 (buses, lorries, large trailers and ambulances and taxis) annual	+ T1b, T2b, T3b, T4.1b, T4.2b and T4.3b (wheeled tractors) 4-2-
Road side inspection (RSI) requirements Target for HDV of 5% of total number of registrations in member state	+ N1 (vans) target of 2%
	+ **Emissions screening 30% of the fleet annually by remote sensing.** + **Emission (and noise) measurement by remote sensing and post verification**: Member States immediately check the emissions of those vehicles either at a roadside check (RSI) or by inviting the owner or holder of the vehicle to a PTI centre within 15 days.
Methods of testing for PTI and RSI Visual inspection	+ Complemented with OBD
Positive ignition: Gaseous emissions idle test of CO and Lambda combined, or OBD check as alternative	- OBD as alternative removed
Compression ignition: Exhaust gas opacity testing, or OBD check as alternative	+ For vehicles that had a particle number (PN) limit at type-approval; Euro VI, Euro 6c and newer for PI, or Euro VI, Euro 5b and newer for CI: **Particle number measurement** in accordance with 8.2.2.1.
	+ For vehicles as of emission classes Euro VI, 6d-TEMP and newer: **NO_X-measurement** in accordance with 8.2.2.3 (PI) and 8.2.3.3 (CI).
Enforcement Tampering or manipulation of components are considered major deficiency.	Tampering or manipulation of components are considered major or dangerous deficiency. (All items w.r.t. emissions including are marked as major deficiency)

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