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Comparative Study on the Differences between the EU and US Legislation on Emissions in the Automotive Sector

STUDY for the EMIS Committee

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Comparative study on the differences between the EU and US legislation on emissions in the automotive sector

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Abstract

This study was commissioned by Policy Department A at the request of the committee of inquiry into emission measurements in the automotive sector (EMIS). It provides a comparative study on the differences between the EU and US legislation on emissions in the automotive sector, covering the emissions standards themselves; the systems for their implementation and enforcement, including approval systems for vehicles; and the respective regimes for prohibiting the use of defeat devices.

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LIST OF ABBREVIATIONS

AECD	Auxiliary Emission Control Device
CAA	Clean Air Act (US)
CAFE	(US) Corporate Average Fuel Economy; (EU) Clean Air for Europe programme
CARB	California Air Resources Board
CF	Conformity Factor
CO_2	Carbon dioxide
CoP	Conformity of Production
DPF	Diesel Particulate Filter
EGR	Exhaust Gas Recirculation
EMIS	Committee on emission measurements in the automotive sector
EPA	(United States) Environmental Protection Agency
GVWR	Gross vehicle weight rating
HDV	Heavy-duty vehicle
ICCT	International Council on Clean Transportation
LDT	Light-duty truck
LEV	Low Emission Vehicle
LNT	Lean NOx Trap
MDPV	Medium-duty passenger vehicle
MNHC	Non-methane hydrocarbon
MY	Model Year
NEDC	New European Driving Cycle
NMOG	Non-methane organic gases
NOx	Nitrogen oxides

NTE	Not-to-exceed limit
OBD	On-board diagnostics
OEM	Original Equipment Manufacturer
PEMS	Portable Emissions Monitoring System
PM	Particulate Matter
RDE	Real Driving Emissions
SCR	Selective Catalyctic Reduction
T&E	Transport and Environment (NGO)
TAA	Type Approval Autority
TCMV	Technical Committee on Motor Vehicles
UNECE	United Nations Economic Commission for Europe
VW	Volkswagen Aktiengesellschaft
WLTP / WLTC	Worldwide harmonized Light Vehicles Test Procedure/ Cycle

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EXECUTIVE SUMMARY

This report was commissioned to assist the European Parliament's Committee of inquiry into Emission Measurements in the Automotive Sector (EMIS) by providing a clear idea of the different regulatory frameworks, stakeholders and actions taken in the EU and the US in the field of emissions from the automotive sector.

The report provides in section 2 an account of the different emissions standards applying in the EU and the US, in respect of both local air quality pollutants, and greenhouse gas emissions, and explains (section 2.4) their development over time. It then explains in detail (section 3) the different approaches in the EU and the US to implementation of standards, including the rules for ensuring that vehicles placed on the market comply with the legislation (through type approval in the EU, and a system of certificates of conformity in the US). It describes the respective test regimes used to determine compliance with emissions standards, and provides a short description of the types of emissions control technologies deployed by manufacturers in the EU and the US to meet the standards.

The respective systems for implementation and enforcement of emissions standards are then described in Section 4, outlining in general terms the impacts on environmental outcomes, particularly in the EU, of the enforcement of emissions standards.

A key question for the EMIS Committee is the use of so-called "defeat devices" (mechanisms which detect the conditions under which the vehicle is operating in order to trigger changes in the operation of emissions control technologies). Given the risk that manufacturers might use such devices to ensure that emissions recorded in tests are more favourable than emissions in real-world performance of the vehicle in normal use and road conditions, defeat devices are in principle banned in both the US and EU. Section 6 therefore sets out a comparison between the two systems and their approach to regulation of defeat devices, starting with the respective definitions, and continuing with an assessment of the enforcement of the ban on defeat devices in the EU and the US respectively.

The final sections identify potential behavioural impacts of weaknesses in the EU system (section 7), before drawing conclusions and offering reflections on the potential future development of policy and legislation in this area, in the light of the current Commission proposal for improvements to the type approval system.

Key findings

Our analysis of the respective **emissions standards** identifies that (broadly) US federal standards are more ambitious for key **local air quality pollutants**, particularly NOx, than EU standards. A key difference is that the US applies a single set of standards to petrol and diesel vehicles, while the EU allows higher levels of air quality pollutants to diesel vehicles. In addition, **California,** and a number of other states which chose to adopt California's rules, apply emissions standards which are more ambitious than federal standards.

With respect to greenhouse gas emissions, while the US has a history of implementing fuel economy standards, this was driven by concerns about energy security rather than climate change; only lately has the US taken action directly on greenhouse gas emissions from vehicles. The EU, in contrast, developed an earlier focus on CO_2 emissions from vehicles; and EU fleet average targets for CO_2 emissions are currently more ambitious than those adopted for emissions in the US.

The **test regimes** used in the EU and the US are, however, different, which affects the stringency in practice of emissions standards. The EU's use of the New European Driving Cycle has hampered the effectiveness of emissions standards. Not only is there a gap between test cycle emissions and real-world driving emissions, but the gap has been growing significantly over time. Progressive introduction of more stringent and representative testing, in the new Worldwide Harmonized Light Vehicles Procedure, which is closer to the US Federal Test Procedure and to real-life driving conditions, will improve the situation.

The current **type approval** system in the EU has a number of weaknesses in comparison with the US system; these derive in part from its origins as a single market instrument rather than a system designed to optimise the effectiveness of environmental legislation. In particular, the flexibility for manufacturers to choose between type approval authorities and testing facilities (including the flexibility to choose different authorities for different elements of type approval) creates a clear risk that manufacturers will use what they perceive to be the least stringent regulator. The US system has a single regulator, the federal Environmental Protection Agency (EPA), which has, in contrast to most Member State type approval authorities, a mission focused on the protection of human health and the environment.

There are also significant contrasts in the stringency of **in-service performance verification.** While the US EPA has a systematic approach to the testing of vehicles at different stages of their life, surveillance in the EU is dependent on the individual Member State, with only very limited efforts to introduce systematic surveillance systems observed. The Commission's current proposal for improving the type approval system addresses this problem, although further detail remains to be set out in implementing legislation.

The definitions of **defeat device** in the US and the EU legislation are fundamentally similar, with a similar range of allowed exemptions. The key difference lies in implementation. In the EU, manufacturers are not obliged to seek prior approval for their reliance on exemptions for defeat devices, or even to identify any such devices when applying for type approval. In the US, manufacturers are required to provide full details of any auxiliary emissions control devices to the EPA. And while in the EU there has been no clarification of how the definition of defeat devices should be implemented, which could have helped to ensure uniformity of understanding among manufacturers and regulatory authorities, the EPA has provided manufacturers and evaluators with a range of advisory circulars providing further interpretative detail.

The **environmental impact** of the discrepancies between test data used for type approval in the EU, and the subsequent real world emissions from vehicles in use, are both **direct**, in the form of significantly higher emissions of (and therefore concentrations of) the relevant pollutants; an issue to which the European Environment Agency has drawn attention since 2004. There is also an important **indirect effect** on policy at EU, national and local level. Policymakers appear to have been slow to address the growing gap between test data and real-world emissions; and in many cases may have relied on optimistic projections based on the introduction of tighter vehicle emissions standards, leading to delays in the introduction of compensating measures at national or local level (such as traffic management) in order to meet the requirements of EU air quality legislation.

In summary, the EU system exhibits a number of structural weaknesses, in addition to the technical weaknesses of the test cycle. We identify some likely **behavioural impacts**, including that **manufacturers** make maximum use of permitted flexibilities; and exploit the scope for choosing type approval authorities they perceive to be more favourable. On the side of the **regulators**, there are few incentives to rigorous identification and pursuit of non-compliance; and the dispersal of responsibility among Member State authorities, and the absence of effective systems for sharing information between themselves and with the Commission, does not facilitate coordinated enforcement action.

Our recommendations identify a number of areas for improvement, some of which are in part addressed by the current Commission proposals. In particular, we consider it important that:

- The flexibility for manufacturers to choose their regulator is removed;
- Oversight of implementation of environmental standards is placed in the hands of organisations with a clear environmental mission;
- Transparency on the use of emission control devices is improved, with manufacturers required to provide full information on them to regulators, and seek prior approval of the use of any defeat devices under specific derogations;
- Greater clarity is provided on the duties of regulators both to monitor in-service performance, and to identify and pursue cases of non-compliance;
- Improved EU-level monitoring of the performance of type approval authorities (TAAs) is introduced, with the option of suspending a TAA's right to issue type approvals in the event of persistent weaknesses in performance.

1. INTRODUCTION

Both in the European Union and in the United States, legislation on vehicle emissions has developed over time to meet a range of policy objectives. The primary driver for legislation is the reduction in environmental impacts, including impacts on human health, and latterly the impacts on climate change, of vehicle emissions. The automotive sector is a key source of a variety of air pollutants including carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), as well as greenhouse gases (GHG). The various emissions have different impacts – hydrocarbons and NOx, for example, contribute to the formation of ground-level ozone, and CO_2 contributes to climate change, while other air toxics and pollutants have other harmful impacts on the environment and on human health.

Legislation on emissions from motor vehicles is just one of a range of issues on which legislation is required for motor vehicle manufacture. Others include safety and roadworthiness of vehicles; the environmentally safe treatment of vehicles at the end of their life; the use of hazardous or environmentally harmful materials in vehicles; and so on. It is important for legislation for each of these issues to meet the legislator's objectives effectively; and it is important for the legislative acquis as a whole to be coherent, and to maximise compliance by manufacturers without imposing unnecessary burdens, particularly unnecessary costs and administrative burdens.

An additional and important justification for legislation at EU level, however, has been the creation and preservation of an internal market for vehicles; if EU Member States were to adopt and enforce standards in different ways, there would be a significant risk that enforcement mechanisms favoured their own domestic producers over imports. Over time, and as an integrated market for vehicle manufacture (including components) and retail has developed, this latter justification has become less prevalent for lawmakers; but it remains an important element in explaining the reliance that EU legislation places on Type Approval mechanisms for ensuring that emissions legislation is complied with.

Internal market issues have been a less relevant issue for the US; while the existence of two sets of emissions standards (federal standards on the one hand, and California's more stringent standards on the other) creates some challenges for inter-state trade, these are relatively easy to address.

The legacy of the single market origin of European legislation on vehicle emissions, however, is significant. The enforcement of standards has been based on the use of mechanisms designed to ensure the free circulation of vehicles on the European market. Subsequent sections of this report will address the weaknesses of this system. While the US system of a single regulator (the EPA) applying environmental controls on the approval of new vehicle types is unlikely to be easily replicable in the EU, due to the absence of a similar federal regulatory system, there is potential for a significant strengthening and clarification of the EU system, in particular to avoid the risk of perverse incentives. The recent Commission proposal[1] takes the first steps in this direction and proposes important improvements.

The emergence of evidence in 2015, following research commissioned in the US by the International Council for Clean Transportation, that VW had installed defeat devices on a range of vehicles, aimed at distinguishing between test cycle and normal conditions, and optimising emissions control for text cycle conditions, has led to a re-examination of the

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[1] COM (2016) 31: Proposal for a Regulation Of The European Parliament And Of The Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles

performance of EU legislation in this area, with a number of enquiries set up at national level and European.

This report contributes to the work of the European Parliament's Committee of Inquiry into emission measurements in the automotive sector, by comparing the regimes applied in the EU and the US in respect of emissions standards, enforcement of those standards through type approval and other mechanisms, and the application of bans on the use of so-called "defeat devices" by manufacturers which lead to a gap between emissions performance in test conditions and in real world driving conditions.

2. REGULATORY EMISSIONS LIMITS IN THE EU AND THE US AND THEIR DEVELOPMENT OVER TIME

The following sections compare the US and EU approaches to, first, regulatory control of emissions affecting air quality, and second, emissions standards related to greenhouse gas emissions and fuel economy. We then provide a detailed explanation of the standards in place, and their development over time.

2.1. Air quality emissions limits in the US and the EU

While the drivers for current legislation on automotive emissions in the European Union and in the United States are the reduction in environmental impacts, and thus similar, the historical background of the respective processes by which legislation has developed is different.

In the United States, federal legislation on vehicle-emissions was passed in the 1960s and 70s – mainly driven by increased levels of ground-level ozone production - smog - in cities, caused by increasing use of motor vehicles in the 1950s and thereafter. Oil price rises and instability in the 1970s were another cause of concern, leading to the adoption of standards for vehicle fuel economy (Corporate average fuel economy, CAFE) in 1975.

The European Union, in comparison, started to regulate vehicle emissions a little later. The initial drivers for legislation in the 1970s were objectives related to vehicle safety and a coherent internal market rather than environmental objectives. Responses to the oil crisis of the 1970s tended to focus on the introduction of fuel taxes of varying intensity at Member State level in order to reduce consumption pressures, rather than the adoption of efficiency standards. It was not until 1992 – after resistance from some EU countries to the mandatory fitting of catalytic converters - that legislation (the “Euro 1” requirements) was passed to set limits for nitrogen oxides emissions (NOx) and tackle acidification and other air quality issues. In effect, tighter limits meant that three-way catalytic converters were eventually required in new petrol cars from the early 1990s.

Catalytic converters in the US, in contrast, were ubiquitous in new cars by the early 1990s, and leaded fuel was largely phased out in the 1990s. In Europe, unleaded fuel became available to coincide with the introduction of catalytic converters, but it was not until 2000 that leaded fuel was largely prohibited across the EU.

EU and US emission regulations are overseen by the European Commission (EC) and the US Environmental Protection Agency (EPA), respectively, although the different nature of the federal systems in the two jurisdictions leads to significant differences in administration (more direct in the US; at arm’s length, through Member State bodies, in the EU). While in the EU, legislators have had a more direct role in the emissions regulatory process, in the US, responsibility for detailed regulation has largely been delegated to federal agencies.

In terms of the level of emission limits relating to air quality, EU emission limits are on average less stringent than those in the US[2]. Within the US, however, two sets of emission limits apply depending on the State concerned (under a system described below), with stricter limits applying in California and a dozen US states which have chosen to follow Californian standards rather than the less ambitious federal ones.[3]

2 Resources for the Future (RFF) (2016) ‘Comparing US and EU Approaches to Regulating Automotive Emissions and Fuel Economy’

3 DieselNet, California Standards (ARB) https://www.dieselnet.com/standards/us/ld.php#arb

When it comes to the control of greenhouse gas emissions, it is the EU that has stricter standards (in addition to generally higher fuel taxes in EU Member States than in the US).

Table 1 below shows a comparison of emissions standards for pollutants in the US (Tier 3) and EU (Euro 6). It should be stressed that the US pursued technically-neutral standards between petrol and diesel cars, unlike the EU which allowed looser standards in NOx and particulates for diesels.

Table 1: Comparison of emission standards for pollutants in the US and EU[4]

Emissions standards for pollutants (g/km)	US	EU
Nitrogen oxides (NOx)	0.04	0.06/0.08*
Non-methane organic gases (NMOG)	0.06	0.07/na*
Carbon monoxide (CO)	2.61	1.0/0.5*
Carbon Dioxide (CO_2, in 2016)	155	130
Carbon Dioxide (CO_2, in 2020)	132	95
Form of vehicle emission testing	**FTP**	**NEDC**
*Petrol / diesel standards Federal Test Procedure (FTP) New European Driving Cycle (NEDC)		

Sources: DieselNet[5] and Delphi (2015)[6]

As shown in Table 1, EU standards differ for petrol as compared to diesel; in the US the same standards apply to both. Historically, diesel cars have played a marginal role in the US market while in approximately half of all cars in the EU sold are diesel cars[7]. This different standards for diesel in the EU reflects a combination of the greater technical challenge in reducing these emissions in diesel vehicles, and a European and Member State policy priority in favour of diesel in the 1980s and beyond, in view of its potential for reducing CO_2 emissions. This was also reflected in lower diesel taxes, which, in combination with the relative fuel efficiency and hence cost-effectiveness of diesel cars are among the reasons for their high market penetration in the EU.

Regulatory differences between the EU and the US in vehicle emission testing regimes are outlined in Sections 3.8 and 3.9. While in the US, the Federal Test Procedure (FTP) is applied, in the EU the New European Drive Cycle (NEDC) is applied. They differ in terms of a range of factors (speed, hot and cold starts,etc.), which makes a comparison difficult. It should also be noted that the EU will soon switch to the new World Light Duty Test Cycle (WLTC) which is more similar to the US cycle; but the US itself has no plans to adopt the WLTC. In developing the WLTC, great efforts were taken to gather data on driving conditions from a

4 All tables and figures are in grams per mile, including US figures, for ease of comparison unless stated otherwise
5 DieselNet, Cars and Light-duty Trucks – Tier 3 https://www.dieselnet.com/standards/us/ld_t3.php
6 Delphi (2015) 'Worldwide Emissions Standards: Passenger Cards and Light Duty Trucks'
7 Congressional Research Service (2014) 'US and EU Motor Vehicle Standards: Issued for Transatlantic Trade Negotiations'

number of countries and to analyse these and reflect them in the new cycle. The resultant cycle is not specific to Europe but is nonetheless representative of modern driving conditions such as those found in Europe. By reflecting high-speed driving, urban motoring conditions, etc it is a much more demanding cycle than the NEDC and much closer in effect to the US FTP.

In addition to the differences in standards for emissions outlined above, Table 2 below[8] shows further differences between US and EU vehicle regulation which will be explained in more detail in chapter 3. Sections 2.2 and 2.3 below outline the standards, and their applying in the US, and the EU, respectively, and explain their development.

Table 2: Summary of main differences between US and EU vehicle regulation

	US	EU
Self-certification for safety regulations	X	
Type-approval for safety regulations		X
Government or government-approved labs used for all testing		X
Type-approval for emissions	X	X
Mutual recognition of regulations by other countries[9]		X
Government sets fleet fuel economy standards[10]	X	
Government sets fleet CO_2 standards[11]	x	x
Fuel economy standard (miles/ gallon) - in 2016 - in 2020	 34.1 38.9	 n/a n/a
Government sets emissions standards	X	x

Source: (Congressional Research Service, 2014)

2.2. Air quality standards in the US

US legislation on air quality and vehicle emissions is a combination of federal law, and (under a waiver from the application of federal standards) stricter Californian standards, which may also be voluntarily applied by other States. The stricter Californian standards are adopted under a system which dates back to the 1950s, when California took the lead in developing

[8] Congressional Research Service (2014) 'US and EU Motor Vehicle Standards: Issued for Transatlantic Trade Negotiations'

[9] Through UNECE, the EU provides mutual recognition to other countries. The United States does not. (Congressional Research Service (2014) 'US and EU Motor Vehicle Standards: Issued for Transatlantic Trade Negotiations')

[10] See section 2.4 for detail on CO_2 and fuel economy standards

[11] See section 2.4 for detail on CO_2 and fuel economy standards

legislation to address air pollution from cars, in response to concerns about smog in major cities. This adoption of state-level standards in advance of the development of federal legislation explains why California retains the right to adopt more stringent controls; and other states have the option of choosing federal standards, or the more demanding Californian ones, but cannot establish any new third standards. California thus remains a key driver in shaping national legislation and regulations.

At federal level, following the establishment of the Clean Air Act (CAA)[12] in 1963 and the subsequent amendments to the Act adopted in 1970, 1977 and 1990, regulations were introduced in order to limit the emissions of certain air pollutants from stationary and mobile sources. The Act authorises the US Environmental Protection Agency (EPA) to set air quality standards and the relevant regulations to protect human health and wellbeing as well as the environment[13]. In common with a US legislative approach developed in several policy areas in the 1960s and 1970s[14] in response to constraints on government action from restrictive Supreme Court judgements, the Act gave relatively broad authority to the federal administration. The key question has thus been whether specific pollutants are deemed to fall under the Act's criteria (a controversial question in relation to CO_2, resolved by the *Massachussets v Environmental Protection Agency* case in 2007[15]); once they are identified as meeting the criteria, and in relation to pollutants already mentioned in the text of the Act, the EPA has broad scope to introduce the emissions standards which it believes are technically achievable. This contrasts to the lawmaking process in the EU, where there is detailed political consideration of new vehicle emissions standards through the process of co-decision in Council and Parliament; and where the Commission has relatively limited powers to adopt and enforce new standards without explicit new legislative endorsement.

In practice, of course, the EPA follows a process of consultation with interested parties; but the sope for political lobbying is, arguably, significantly lower. Development of standards typically involves new regulations being put forward by the regulator for public discussion and then, if it is decided that they should be introduced in either the original or modified form, signed into law.

2.2.1. The development of federal standards over time

When smog became a serious health concern in the 1950s – particularly in the Los Angeles basin with its unique weather conditions – California took the lead in developing legislation to curb auto emissions. In 1959, the Motor Vehicle Pollution Control Act was passed in California. At the federal level, the development of legislation was based on research efforts to understand the extent of, and mechanisms for, air pollution problems. In 1955, the Air Pollution Control Act was passed at the federal level, providing funds for research on air pollution. In 1963, the first legislation at federal level with the objective of comformity air pollution was passed, in the fom of the Clean Air Act; and a few years later, in 1968, Congress adopted California's 1965 vehicle emissions standards at federal level.

In 1970, amendments to the Clean Air Act were passed that required regulatory controls for air pollution. The amendments also meant a stricter federal enforcement. In the same year, the EPA was established for standard-setting and enforcement activities. Among the first

[12] U.S. Senate, Clean Air Act http://www.epw.senate.gov/envlaws/cleanair.pdf

[13] The United States Environmental Protection Agency, Emissions Standards Reference Guide for On-road and Nonroad Vehicles and Engines https://www.epa.gov/emission-standards-reference-guide

[14] Shapiro S and Glicksman R (1988), « Congress, the Supreme Court, and the Quiet Revolution in Administrative Law ». Duke Law Journal Vol. 1988, No. 5 (Nov, 1988), pp. 819-878

[15] Supreme Court of the United States, No. 05-1120, Massachussets et al. v. Environmental Protection Agency et al.

major initiatives was the phasing out of lead as a petrol additive which was crucial in developing catalytic technology.

The 1977 amendments to the Clear Air Act brought changes to the specifications of Naional Ambient Air Quality Standards (NAAQS). In particular, new requirements were put in place to ensure that these standards were met and maintained over time, with implications for the future development of vehicle emission standards[16].

In 1990, further amendments to the Clean Air Act set "Tier 1" standards applicable to all new vehicles, covering CO, NOx, PM and HC. Under Tier 1, a set of different standards for different vehicle categories were defined. In 2000, EPA promulgated “Tier 2” standards which were stricter, and in 2014, “Tier 3” standards were passed which are in force now. Details about the development of standards can be found in Annex 2.

Under the current EPA regulation, the same emission limits apply to all vehicles irrespective of whether they use diesel or petrol. Further, the same emission standards apply to all vehicles irrespective of their weight but based on the car’s footprint – i.e. the approximate size of the rectangle defined by the four wheels.

<u>Development of Tiers</u>

Currently,”Tier 3” standards are in place. The development of standards by Tiers is briefly outlined below, and in detail in Annex 2.

With the introduction of each new set of regulations came progressively more stringent limitations on emissions levels as well as new standards and a wider coverage of heavier categories of vehicles (see Table 3 below). Manufacturers are given a phase-in period within which they are legally required to ensure that an increasing proportion of their new vehicles and motors meet the relevant standards. Older vehicles must also continue to meet the preceding regulations, under which they were certified.

[16] The US EPA, Clean Air Act Amendments of 1997, https://www.epa.gov/clean-air-act-overview/evolution-clean-air-act#caa77

Table 3: Developments in US Automotive Emissions Standards since 1990

Standard	Date of Adoption	Phase-in Schedule	Applicable Vehicles
Tier 1	5 Jun 1991	1994-1997	All new LDVs where GVWR < 8,500 lbs
Tier 2	21 Dec 1999	2004-2009*	Tier 1 vehicles All new MDPVs where 8,500lbs <GVWR> 10,000lbs
Tier 3	3 Mar 2014	2017-2025	Tier 1 vehicles Tier 2 vehicles All new HDVs where GVWR < 14,000lbs

*Passengers cars and LLDTs 2004-2007; HLDTs and MDPVs -2009
LDVs – Light-duty vehicles
LLDTs – Light light-duty trucks (< 6,000lbs)
HLDTs – Heavy light-duty trucks (> 6,000lbs)
MDPV – Medium-duty passenger vehicles (> 8,500lbs, <10,000lbs)
HDVs – Heavy-duty vehicles
GVWR – Gross vehicle weight rating

2.2.2. California Standards

As noted above, in addition to these federal regulations, California, through its Air Resources Board (CARB), has adopted separate, more stringent emission regulations. These are known as the Low Emission Vehicle (LEV) standards (see Table 4) and are developed by the CARB on the basis of California air quality legislation[17]. Although they are more stringent than the federal standards, they are relatively similar in structure to the EPA legislation[18]. Other states may, and many have[19], choose to adopt these more rigorous requirements in place of those implemented federally.

Table 4: Developments in California Automotive Emissions Standards

Standard	Date of Adoption	Phase-in Schedule	Applicable Vehicles
LEV I	1990	1994-2003	Light-duty and medium-duty vehicles (up to 14,000lbs GVW)
LEV II	Aug 1999	2004-2010	LEV I vehicles (incl. reclassification of categories based on weight)
LEV III	Jan 2012	2015-2020	Same as LEV II

Part of California's regulations requires vehicles acquired from outside of the state to meet their specific emissions standards. If standards are not met, vehicles would need to be modified in order to be eligible for registration within the state. Manufacturers must ensure

[17] California Air Resources Board, Air Quality Legislation http://www.arb.ca.gov/legis/legis.htm
[18] California Environmental Protection Agency Air Resources Board, Low-Emission Vehicle Program https://www.arb.ca.gov/msprog/levprog/levprog.htm
[19] States adopting the more stringent California LEVII are New Jersey, Connecticut, Washington, Vermont, New York, Maine, Rhode Island, Massachusetts, Oregon, Arizona, Pennsylvania, Maryland, Florida and New Mexico. (DieselNet, Emission Standards, https://www.dieselnet.com/standards/us/ld.php#arb)

that cars are 'California Certified' rather than just 'Federally Certified' if they wish their vehicles to be sold and used within the state of California[20].

Table 5: US & California emission standards for petrol passenger cars at 50,000 miles/ 5 years (100,000 miles/10 years) (g/km)

Model Year - Standard	CO	NMHC/ NMOG	NOx
1994 - LEV	2.11 (2.61)	0.05 (0.06)	0.12 (0.19)
1994 - Tier 1	2.11 (2.61)	0.16 (0.19)	0.25 (0.37)
2004 - LEV II: LEV	2.11 (2.61)	0.05 (0.06)	0.03 (0.04)
2004 - Tier 2: Bin 5	2.11 (2.61)	0.05 (0.06)	0.03 (0.04)
2015 - LEV III: LEV160	2.11	0.06	0.04
2017 - Tier 3: Bin 160	2.11	0.06	0.04

2.3. Air quality standards in the EU

Vehicle emission limits in the EU are regulated by "Euro emission standards" as set out in the EU framework for the type approval of cars, vans, trucks, buses and coaches (Directive 2007/46/EC), and in specific legislation determing limit values, notably Regulation 715/2007 (EC) on emissions from light passenger and commercial vehicles[21], and subsequent amendments. Since the adoption of the initial standards which later became known as "Euro 1", stricter standards have been progressively adopted over time, as illustrated in Table 6 below; historical background on this process is provided in section 1.1.1 below. The current standards are: for light duty vehicles (cars and vans) Euro 6, while the current standard for heavy duty vehicles is Euro VI. Euro 5 and 6 Regulations set the emission limits for cars for regulated pollutants, in particular nitrogen oxides (NOx, i.e. the combined emissions of NO and NO_2) of 80mg/km for diesel, and 60mg/km for petrol.

It should be noted that the stringency in practice of the emissions standards set out in EU legislation is significantly dependent on the process and test regime for type approval, which is addressed in section 3.

[20] Air Resources Board (2016), 'Before you buy a car out of state…' https://www.arb.ca.gov/msprog/NonCAVeh/NonCAVeh.pdf

[21] Regulation (EC) 715/2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information

Table 6: EU emission standards for passenger cars (g/km)

Stage	Date	CO	HC	HC+ NOx	NOx	PM	Stage	Date	CO	HC	HC+ NOx	NOx	PM
Compression Ignition (Diesel)							**Positive Ignition (Petrol)**						
Euro 1†	Jul 1992	1.0	-	0.97 (1.13)	-	0.14 (0.18)	Euro 1†	Jul 1992	2.2	-	0.97 (1.13)	-	-
Euro 2, IDI	Jan 1996	1.0	-	0.7	-	0.08	Euro 2	Jan 1996	2.3	0.20	0.5	-	-
Euro 2, DI	Jan 1996[a]	0.64	-	0.9	-	0.10							
Euro 3	Jan 2000	0.50	-	0.56	0.50	0.05	Euro 3	Jan 2000	1.0	0.10	-	0.15	-
Euro 4	Jan 2005	0.50	-	0.30	0.25	0.025	Euro 4	Jan 2005	1.0	0.10[d]	-	0.08	-
Euro 5a	Sept 2009[b]	0.50	-	0.23	0.18	0.005[f]	Euro 5	Sept 2009[b]	1.0	0.10[d]	-	0.06	0.005[e,f]
Euro 5b	Sept 2011[c]	0.50	-	0.23	0.18	0.005[f]							
Euro 6	Sept 2014	0.5		0.17	0.08	0.005[f]	Euro 6	Sept 2014	1.0	0.10[d]	-	0.06	0.005[e,f]

* At the Euro 1..-4 stages, passenger vehicles > 2,500 kg were type approved as Category N1 vehicles
† Values in brackets are conformity of production (COP) limits
a. until 1999.09.30 (after that date DI engines must meet the IDI limits)
b. 2011.01 for all models
c. 2013.01 for all models
d. and NMHC = 0.068 g/km
e. applicable only to vehicles using DI engines
f. 0.0045 g/km using the PMP measurement procedure
g. 6.0×1012 1/km within first three years from Euro 6 effective dates

Source: Dieselnet[22]

[22] Dieselnet (2016), EU Emission Standards https://www.dieselnet.com/standards/eu/ld.php#stds

Table 7: EU Emission Standards for Light Commercial Vehicles, Compression ignition (Diesel) (g/km)

Category†	Stage	Date	CO	HC	HC+ NOx	NOx	PM
N_1, Class I ≤1305 kg	Euro 1	Oct 1994	2.72	-	0.97	-	0.14
	Euro 2 IDI	Jan 1998	1.0	-	0.70	-	0.08
	Euro 2 DI	Jan 1998[a]	1.0	-	0.90	-	0.10
	Euro 3	Jan 2000	0.64	-	0.56	0.50	0.05
	Euro 4	Jan 2005	0.50	-	0.30	0.25	0.025
	Euro 5a	Sept 2009[b]	0.50	-	0.23	0.18	0.005[f]
	Euro 5b	Oct 2011[d]	0.50	-	0.23	0.18	0.005[f]
	Euro 6	Sept 2014	0.50	-	0.17	0.08	0.005[f]
N_1, Class II 1305-1760 kg	Euro 1	Oct 1994	5.17	-	1.40	-	0.19
	Euro 2 IDI	Jan 1998	1.25	-	1.0	-	0.12
	Euro 2 DI	Jan 1998[a]	1.25	-	1.30	-	0.14
	Euro 3	Jan 2001	0.80	-	0.72	0.65	0.07
	Euro 4	Jan 2006	0.63	-	0.39	0.33	0.04
	Euro 5a	Sept 2010[c]	0.63	-	0.295	0.235	0.005[f]
	Euro 5b	Sept 2011[d]	0.63	-	0.295	0.235	0.005[f]
	Euro 6	Sept 2015	0.63	-	0.195	0.105	0.005[f]
N_1, Class III >1760 kg	Euro 1	Oct 1994	6.90	-	1.70	-	0.25
	Euro 2 IDI	Jan 1998	1.5	-	1.20	-	0.17
	Euro 2 DI	Jan 1998[a]	1.5	-	1.60	-	0.20
	Euro 3	Jan 2001	0.95	-	0.86	0.78	0.10
	Euro 4	Jan 2006	0.74	-	0.46	0.39	0.06
	Euro 5a	Sept 2010[c]	0.74	-	0.350	0.280	0.005[f]
	Euro 5b	Sept 2011[d]	0.74	-	0.350	0.280	0.005[f]

† For Euro 1/2 the Category N1 reference mass classes were Class I ≤ 1250 kg, Class II 1250-1700 kg, Class III > 1700 kg
a. until 1999.09.30 (after that date DI engines must meet the IDI limits)
b. 2011.01 for all models
c. 2012.01 for all models
d. 2013.01 for all models
e. applicable only to vehicles using DI engines; f. 0.0045 g/km using the PMP measurement procedure

Source: Dieselnet[23]

[23] Dieselnet (2016), EU Emission Standards https://www.dieselnet.com/standards/eu/ld.php#stds

2.3.1. How did EU standards develop over time?

The initial EU legislation on emissions from vehicles dates from 1970. While EU action was a response to growing concerns on air quality, and to the adoption of Member State measures aimed at improving emissions standards, the rationale for EU involvement was primarily concerned not with achieving particular environmental objectives, but with ensuring that Member State measures relating to the safety and local environmental impacts of vehicles did not disrupt the internal market. Thus, Directive 70/220 EC[24], adopted by the initial 6 Member States of the EU, explicitly responds to the adoption of legislation on vehicle emissions in Germany and France respectively, which in turn appear to have been inspired in part by the progressive development of legislation in the US. The proposal noted that such Member State legislation was "liable to hinder the establishment and proper functioning of the common market", and the directive therefore ensures that Member States are not allowed either to refuse type approval to vehicles which comply with its requirements on carbon monoxide and hydrocarbon emissions, or to refuse to register or allow the use of such vehicles. It should be noted that it was, therefore, still possible for vehicles not meeting these standards to be manufactured and used in individual Member States; although in practice the market for such vehicles was relatively small.

Further development of standards in the 1980s responded to growing public pressure in Germany, Denmark, and the Netherlands for action to tackle acidification and other air quality issues, including in particular calls for mandatory fitting of catalytic convertors (again, partly in response to US regulatory progress). This approach was opposed by Member States such as France, the UK, and Italy, where the average size (and price) of vehicle manufactured was smaller, and in consequence the percentage price impactof installing catalytic convertors would have been greater. German manufacturers, in contrast, were already selling cars in California so they were familiar with catalytic converter technology, and could more easily accommodate it within the size and price range of their cars.

A Commission proposal for a strengthening of standards was tabled in 1984, aimed in part at forestalling the risk of unilateral national measures which would have disrupted the internal market. The proposal did not make progress until the introduction of Qualified Majority Voting under the Single European Act in 1987, leading to the adoption of a compromise in December 1987 that applied only to large cars of the types more prevalent in Germany, and towards the luxury end of the EU market.

Follow-up legislation on second-stage reductions for small cars[25] was adopted in 1989[26], and was powerfully influenced by the use of the cooperation procedure by the European Parliament, supported by the Commission, to significantly strengthen the Council's common position, in order to make three-way catalytic converters obligatory. The Council accepted the more stringent standards (19 g/test for CO, 5 g/test for HC and NOx); and also the innovation that Member States no longer had a choice on the timing of implementation of the new standards, which were compulsory from 1992.

The adoption of relatively stringent standards for smaller cars in Directive 89/458/EEC created, in turn, a favourable policy climate for a further tightening of emission limits for medium and large cars. A Commission proposal requiring all new-model cars to meet

[24] Council Directive of 20 March 1970 on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles

[25] COM(1987)706 - Amendment of Directive 70/220/EEC on the approximation of the laws of statesMember Statesstates relating to measures to be taken against air pollution by gases from the engines of motor vehicles (European emission standard for cars below 1.4 litres)

[26] Council Directive 89/458/EEC of 18 July 1989 amending with regard to European emission standards for cars below 1,4 litres, Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles.

standards which were effectively equivalent to those applying in the US from 31 July 1992[27] was adopted as Directive 91/441/EEC.

Further improvements in legislative standards in the following years focused in particular on cleaner fuels, partly in response to concerns about the costs of future vehicle technology requirements; the Commission established the European Auto-Oil Programme, which led to the adoption of a Directive on the Quality of Petrol and Diesel (Directive 98/69/EC), which included the introduction of emissions limits for cold starts, and led to a requirement that all positive ignition engines should be fitted with on-board diagnostic systems.

A progressive integration of policies on sources of emissions, and on the setting of environmental standards, can be observed from 2000 onwards, in the development of the Clean Air for Europe (CAFÉ) programme[28]; and Community standards, having initially been developed in a piecemeal manner for different vehicle types and pollutants, were increasingly developed in a more coherent way under the Auto Oil framework.

The publication of the CAFÉ communication in 2001, together with the adoption of the Sixth Environmental Action Programme[29] (under co-decision with the European Parliament) in 2002, with its emphasis on the adoption of thematic strategies to deliver a broad agenda of improvement in key policy areas, led to the adoption by the Commission of its thematic strategy on air pollution in 2005[30]. The strategy concluded that further emissions reductions were required, including in vehicle emissions, in order to achieve the required improvements in air quality. Work began on the development of Euro 5 and 6 standards for cars and vans, which were adopted by the co-legislators in 2007[31], and are described in detail above.

2.4. EU and US legislation on greenhouse gas emissions

EU and US legislation on greenhouse gases differs both in terms of its historical development and in terms of how targets are set and measured. Comparing the standards is challenging because of differences in the underlying test cycles in which GHG emissions are measured. Details of the test cycles will be outlined further in Section 3.

In the US, as noted above, CO_2 emissions have been indirectly addressed since 1975 through the Corporate Average Fuel Economy (CAFE) standards enforced by the National Highway Traffic Safety Administration (NHTSA), and adopted under the Energy Policy and Conservation Act voted by Congress in 1975 in the wake of the 1973/4 oil price shock. CAFE standards apply for all light duty vehicles (LDV) which comprise passenger cars and light duty trucks under 3.856kg.[32]

Until a few years ago, the key driver behind standards in the US was the objective of decreasing dependency on oil imports and economic exposure to oil price fluctuation. It has only been recently – under the Obama administration – that specific CO_2 targets have been set for vehicles[33].

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27 Tier 1 standards, as defined in 1990. See section 2 below

28 COM(2001) 245 final, Communication from the Commission "The Clean Air for Europe (CAFE) Programme: Towards a Thematic Strategy for Air Quality"

29 Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme of 10 September 2002

30 COM (2005) 446 final, Communication from the Commission to the Council and the European Parliament : Thematic Strategy on air pollution

31 Regulation (EC) 715/2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information

32 RWTH Aachen (2012) , CO_2-Reduzierungspotenziale bei PKW bis 2020'

33 RWTH Aachen (2012) , CO_2-Reduzierungspotenziale bei PKW bis 2020'

Thus, in the US, currently two sets of legislation for fuel efficiency and CO_2 exist side by side; the CAFE standards set by the NHTSA, which govern fuel economy; and EPA standards for CO_2 emissions. Both sets of legislation are based on the vehicle's footprint.

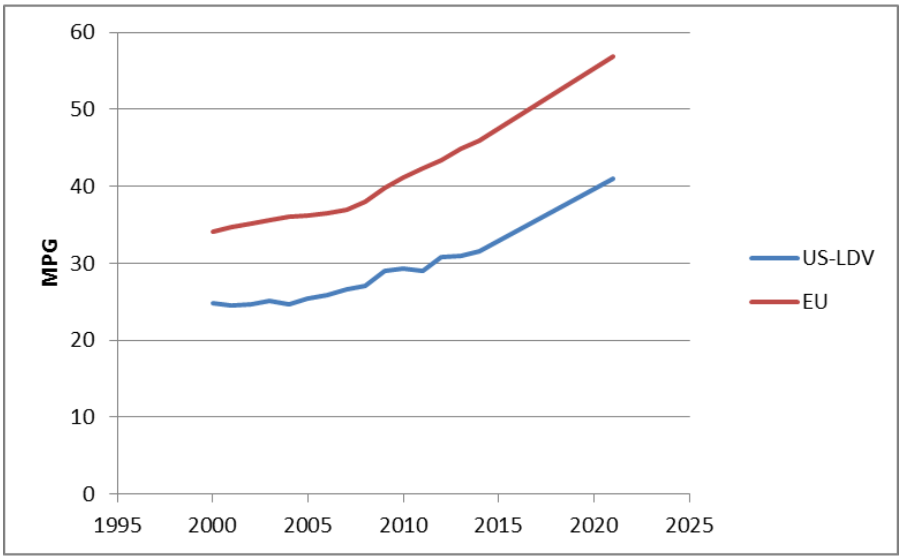
In the EU, standards are set for GHG emissions in grams emitted per kilometre driven (g/km)[34]. The first CO_2 targets in the EU were set as early as 1998 through voluntary agreements between the automotive industry and the European Commission, and later through mandatory emission reduction targets set in legislation as outlined in section 2.5 below.

One area in which GHG standards in the US and EU differ is in how emissions are calculated. In the US, all GHG emissions from vehicles are counted in terms of their CO_2-equivalents (e.g. CO_2, N_2O and CH4). In contrast, the EU regulates only CO_2.

Additionally, while the EU, after some debate during the development of and adoption of the regulation on CO_2 emissions from passenger cars[35], sets its GHG emissions standards (see section 2.6 below) on a fleet-average basis calculated by the mass of each vehicle, the fleet-average standards in the US are based on the "vehicle footprint".[36] The latter approach has the advantage that manufacturers have a stronger incentive to reduce emissions by the use of lighter materials, as well as other methods.

Figure 1 shows an estimate of past and projected future standards in the EU and US and their impact on fuel economy, based on calculations by the International Council for Clean Transportation (ICCT). These data suggest that in general, EU standards are more demanding than those in the US; reflecting both the earlier focus of EU legislators on CO_2 emissions, and the different vehicle fleet make-up in the two economies.

Figure 1: Comparison of Historical and Proposed U.S. and EU Fuel Economy Standards for Light-Duty Vehicles on the CAFE Test Cycle



Source: ICCT data

[34] Stricter CO_2 limits will indirectly improve fuel-efficiency.

[35] Regulation (EC) 443/2009, as amended by Regulation (EU) 333/2014

[36] Congressional Research Service (2014) 'US and EU Motor Vehicle Standards: Issued for Transatlantic Trade Negotiations'

2.5. EU legislation on greenhouse gas emissions

Efforts to reduce CO_2 from passenger cars in the aftermath of the conclusion of the Kyoto Protocol in the EU date back to 1998 when a voluntary agreement was reached between the European Commission and the Association of European Automobile Manufacturers (ACEA). Under the agreement, the industry committed to reduce average CO_2 emission figures from all new cars to 140 g/km by 2008. This compared to the then current level of emissions of about 186 g/km.[37] Similar agreements with the Japanese and Korean manufacturers followed.

Annual reporting on these efforts, however, demonstrated that while some progress was being made in reducing emissions, manufacturers collectively were failing to meet their own commitments, and in 2009, mandatory CO_2 standards for all new passenger cars were introduced. The 2009 Regulation (EC) No 443/2009 established a 2015 target of 130 g/km for the fleet average of all manufacturers combined. Individual manufacturers were allowed a higher or lower CO_2 emission value, depending on the average vehicle weight of their fleet. The heavier the average weight of the cars sold by a manufacturer, the higher the CO_2 level allowed. A similar CO_2 standard for new light-commercial vehicles was introduced in 2011. It sets a target of 175 g/km for 2017[38].

In parallel with this process, legislation was developed to provide buyers with information on the fuel economy and CO_2 emissions of new cars at the point of sale, in order to guide them towards more fuel-efficient models and thereby encourage manufacturers to adapt to this evolving demand. The EU Car Labelling Directive (Directive 1999/94/EC) requires each Member State to ensure that a label on fuel economy and vehicle emissions, meeting the information criteria laid down in the directive, is "attached to or displayed, in a clearly visible manner, near each new passenger car model at the point of sale", and accompanied by further provision of the relevant information in posters and information in any promotional literature.

To improve the fuel economy of cars sold on the European market, targets were reinforced at the end of 2013, and the European Parliament and the Council of the European Union reached an agreement regarding two regulatory proposals for mandatory 2020 CO_2 emission targets. Passenger car standards are set at 95 g/km of CO_2, phasing in for 95% of vehicles in 2020 with 100% compliance in 2021. Light-commercial vehicle standards are 147 g/km of CO_2 for 2020. The 95 g/km target implies a fuel consumption of around 4.1 l/100 km of petrol or 3.6 l/100 km of diesel.

The 2015 and 2021 targets represent reductions of 18% and 40% respectively compared with the 2007 fleet average of 158.7g/km[39].

The revised legislation also includes a review clause to establish CO_2 emission targets for the period beyond 2020. By 31 December 2015, the European Commission was required to review the emission targets, modalities, and other aspects of the regulation needed to set standards beyond 2020. The review clause also requires targets to be set so as to maintain a "clear emissions reduction trajectory, comparable to that achieved in the period to 2020". The European Parliament's Environment Committee recommended, in its report at first reading, an indicative target range of 68–78 g/km for 2025; however, this momentum was

[37] Eur-Lex (2016). CO_2 emissions from new passenger cars: monitoring. Summaries of EU legislation. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:l28055

[38] ICCT (2014), Development of test cycle conversion factors among worldwide light duty vehicle CO_2 emission standards.

[39] European Commission Climate Action: Reducing CO_2 emissions from passenger cars. Available at: http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm

not taken up in the Regulation subsequently adopted at first reading[40].

For electric vehicles, special provisions apply in terms of measuring CO_2 emissions[41], known as supercredits.[42] This idea was inspired by the similar approach in US legislation, and essentially allowed a qualifying electric car to be given an enhanced weighting towards meeting a manufacturer's sales-weighted average, thereby creating an additional incentive for development and deployment of new electric vehicle technologies.

2.6. US legislation on greenhouse gas emissions

In addition to air quality standards, federal legislation has also tackled fuel economy (although not, until more recently, directly addressing greenhouse gas emissions). The CAFE (corporate average fuel economy) standards on fuel economy date back to the 1970s when oil prices and imports became a concern. The CAFE mechanism has been refined over the years, and differs from the EU's approach to GHG emissions regulation, where a vehicle's weight is the basis for standards[43], by applying standards on the basis of the vehicle's footprint[44] (thereby encouraging the use of lighter materials as a mechanism for achieving fuel economy improvements).

Policy on automotive emissions standards first began to focus directly on CO_2 emissions in 2007 when the US Supreme Court ruled that as it was a pollutant covered by the Clean Air Act (CAA), the management of vehicular emissions of CO_2 was the responsibility of the EPA under the Act fell under the jurisdiction of the EPA. Emission standards for CO_2 were therefore introduced in 2010 by the EPA, working together with the National Highway Traffic Safety Administration (NHTSA), which has historically been responsible for the CAFE fuel efficiency standards; the new standards applied to vehicles manufactured from 2012, based still on corporate averages.

For model year (MY) 2012-2016 light-duty vehicles, CO_2 emissions were limited to 155 g/km. More progressive standards were established in 2012 for 2017-2025 MY vehicles that required an average level of 101 g/km CO_2 emissions[45]. CO_2 emissions standards were very stringent with no flexibility in terms of non-compliance. That said, the EPA did provide Temporary Lead-time Allowance Alternative Standards (TLAAS) for certain manufactures facing severe compliance difficulties due to their limited product lines.

[40] Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new passenger cars

[42] Further info : IW Köln (2013) ' CO_2-Regulierung für PKW: Fragen und Antworten zu den europäischen Grenzwerten für Fahrzeughersteller'

[42] Further info : IW Köln (2013) ' CO_2-Regulierung für PKW: Fragen und Antworten zu den europäischen Grenzwerten für Fahrzeughersteller'

[43] CO_2 consumption is directly proportional to a vehicle's weight

[44] "Consequently, automakers who sell larger vehicles are subject to lower fuel economy requirements. Because of this relationship between a vehicle's footprint and its fuel economy requirement, the recent decline in petrol prices, which caused sales to shift toward larger vehicles, has reduced the overall level of fuel economy required by the standards, albeit only slightly." Source: Resources for the Future (RFF) (2016) 'Comparing US and EU Approaches to Regulating Automotive Emissions and Fuel Economy'

[45] DieselNet, Emission Standards, GHG Emissions and Fuel Economy https://www.dieselnet.com/standards/us/fe_ghg.php

CO_2 Standards for 2012-2016

Emissions standards for CO_2 are dependent on the size of the vehicle i.e. the larger the vehicle, the larger the permitted emission level (see Table 8).

Table 8: Projected fleet wide CO_2 compliance (g/km)

Vehicle Category & Standard	Model Year				
	2012	2013	2014	2015	2016
Passenger cars	163	159	152	147	140
Light trucks	215	209	203	194	185
Combined Cars & Trucks	183	178	171	163	155

Source: EPA[46]

In addition to CO_2 emissions, the GHG standard specified N2O and CH4 tailpipe emissions which were set at 0.006 g/km and 0.02 g/km respectively. Manufacturers could, if they wished, use a CO_2-equivalent standard for N_20 and CH_4 standards where a CO_2-equivalent of 185 and 15.5 are to be used respectively.

In its infancy, the programme allows for certain leeway pertaining to various credits/deficits of a fleet's average CO_2 emissions e.g. early implementation of standards. As with the current CO_2 standards, the CO_2 emissions regulation due to be applied from 2017 is based on vehicle size (see Table 9).

Table 9: Projected 2017-2025 fleet wide CO_2 compliance levels (g/km)

Vehicle Category & Standard	Model Year								
	2017	2018	2019	2020	2021	2022	2023	2024	2025
Passenger cars	132	126	119	113	107	102	98	93	89
Light trucks	183	177	172	167	155	147	140	133	126
Combined Cars & Trucks	151	144	138	132	124	118	112	106	101

Source; adapted by IEEP from DieselNet[47]

46 The USEPA, 2010, Regulatory Announcement: EPA and NHTAS finalise historic national program to reduce greenhouse gases and improve fuel economy for cars and trucks

47 DieselNet, Emission Standards, GHG Emissions and Fuel Economy https://www.dieselnet.com/standards/us/fe_ghg.php

In addition to the above CO_2 emission standards, N_2O and CH_4 standards are applied to 2017-2025 vehicles but remain at the levels specified in the 2012-2016 regulation.

Flexibility is allowed regarding the averaging, banking and trading (ABT) of CO_2 emission credits and deficits. The EPA is also introducing numerous early-adoption incentives for electric vehicles, hybrid technologies and alternative fuel vehicles. Due to the long-term scope of these standards, the EPA, along with NHTSA, will conduct a mid-term review to assess progress.

2.7. Technologies used in light vehicles to comply with emissions legislation

The increasing stringency of emissions standards for cars has gradually forced vehicle manufacturers to apply more sophisticated engine control systems and calibration strategies, and to introduce more sophisticated aftertreatment technologies such as those described below. From the outset, the Euro 1 emission standard had the effect and the intention of requiring positive ignition-engined (PI or spark ignition – mainly petrol) cars to be fitted with three-way catalytic converters. These have become both cheaper and more sophisticated over time and have, broadly speaking, been effective in delivering real-world emissions reductions of regulated pollutants in line with the tightening standards.

Stringent standards for NOx and particulates came more slowly for diesel cars and vans, but sophisticated technologies are now needed for light duty diesels as well. Unlike with petrol, no one technology has so far prevailed, and currently, a vehicle complying fully to Euro 6 standards will need a combination of different in-engine and aftertreatment technologies.

The operating principle of the diesel engine is to inject the fuel directly into the cylinder, in which there is more air available than needed for the combustion of the fuel (known as lean burning). As a result, fuel efficiency is high and CO and HC emissions are generally very low; but the excess air in combination with a high combustion temperature encourages the formation of NOx in particular. The fuel directly injected into the cylinder can also lead to particulate (PM) formation due to imperfect fuel-air mixing and incomplete combustion.

2.7.1. Diesel engine management

The NOx emissions can be influenced simply by changing the timing of the fuel injection: late injection reduces the engine-out NOx emissions but at some cost in fuel efficiency and vice versa. This trade-off leads to an incentive for manufacturers to calibrate their engines towards low emissions during the test cycle, while for those conditions not encountered during the test procedure the primary aim is to improve fuel economy. Up to and including Euro 5 NOx standards, this and other minor adjustments were often sufficient to meet the relatively lax test limits, but to meet the more stringent Euro 6 limit more advanced reduction technologies are now needed, as set out below.

2.7.2. Exhaust gas recirculation (EGR)

EGR recirculates some of the exhaust gas back into the engine. As a result there is less oxygen available in the cylinder for combustion, leading to a lower combustion temperature and in turn to less NOx production. The rate of EGR that can be applied depends on various engine parameters, of which engine load is the most important, as high engine load requires more oxygen. This can tempt manufacturers to apply lower EGR rates (or none) for conditions outside the operating envelope of the NEDC and hence allow higher real-world NOx. Up to and including Euro 5 standards, EGR was often sufficient on its own to meet the test limits, but from Euro 6 EGR is now usually used in combination with other abatement technologies (SCR or LNT – see below), although it is reported that improved EGR systems can now comply with Euro 6 NOx limits by combining two EGR circuits.

2.7.3. Lean NOx trap (LNT)

The lean NOx trap is a catalytic converter that combines an oxidation catalyst, an adsorber to store NO_2 under lean-burn conditions, and a reduction catalyst. Once the adsorber is saturated, unburnt fuel must be injected for a short time to deliver reducing compounds such as HC, CO and hydrogen so that the NOx is desorbed and reduced to nitrogen. LNT technology is reportedly capable of NOx reductions up to a level of 70 to 90% in most driving conditions, but like most aftertreatment devices, there is a fuel penalty involved for the regeneration cycles. An early analysis by the ICCT on the phase-in stage of Euro 6 standards for diesel cars, based on reliable data sources, suggested that LNTs performed particularly poorly on the more realistic WLTP test cycle[48].

2.7.4. Selective catalytic reduction (SCR)

SCR is an advanced and active control technology involving a catalytic converter that can reduce NOx to nitrogen through the use of an external reducing agent, usually a urea-based liquid known in Europe as AdBlue®. This is stored in a separate tank in the vehicle. For cars this is ideally refilled during routine servicing, but in practice additional refills between services are needed for high-mileage cars. This requirement is seen as a drawback of SCR by carmakers, as they consider it undesirable for motorists to have to refill an extra tank between service intervals if they run out of AdBlue®.

The catalyst operates at a high temperature (above 190°C approximately), so it does not work until the engine is warmed up or potentially during short trips with low engine loads and frequent stops. An SCR system can achieve NOx conversion rates of up to 80-95%, depending on the rate of application of the AdBlue®; but concerns over running out of AdBlue® between service intervals can encourage underdosing of the SCR, which results in higher NOx emissions. Nonetheless, SCR is considered the 'gold standard' of the available technologies[49]. Heavy duty vehicles have been equipped with SCR technology for about ten years and it appears to function well across a range of driving conditions, but it is still a relatively new development for light duty vehicles. It was pioneered for cars in Europe primarily to serve the US market where NOx standards were more stringent. As a result it tends still to be most common on larger and more expensive cars, where the volume of an extra tank and the higher cost of the equipment can be most easily accommodated in the price.

2.7.5. Diesel particulate filter (DPF)

This technology involves a wall flow filter which will physically trap the solid particulate matter from the exhaust gas, including the solid carbon fraction and fine particles. The filter then has to undergo a regular regeneration process to remove the accumulated particles. Again this process incurs a small fuel penalty, and is best undertaken during long, high-speed trips. The DPF must therefore be integrated into the engine control system to ensure reliable regeneration. The particulate reduction rates of DPFs are high, reportedly at least 90-95%. Again, heavy duty vehicles have used this technology for some time, but diesel cars and vans are also expected to be equipped with a DPF to meet the Euro 5 and 6 particulate limits or beyond.

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[48] ICCT (2015). NOx Control Technologies for EURO 6 Diesel Passenger Cars. ICCT White Paper. http://www.theicct.org/sites/default/files/publications/ICCT_NOx-control-tech_revised10132015.pdf

[49] See for example, Diesel Technology Forum (2016). About Clean Diesel : What is SCR ? http://www.dieselforum.org/about-clean-diesel/what-is-scr

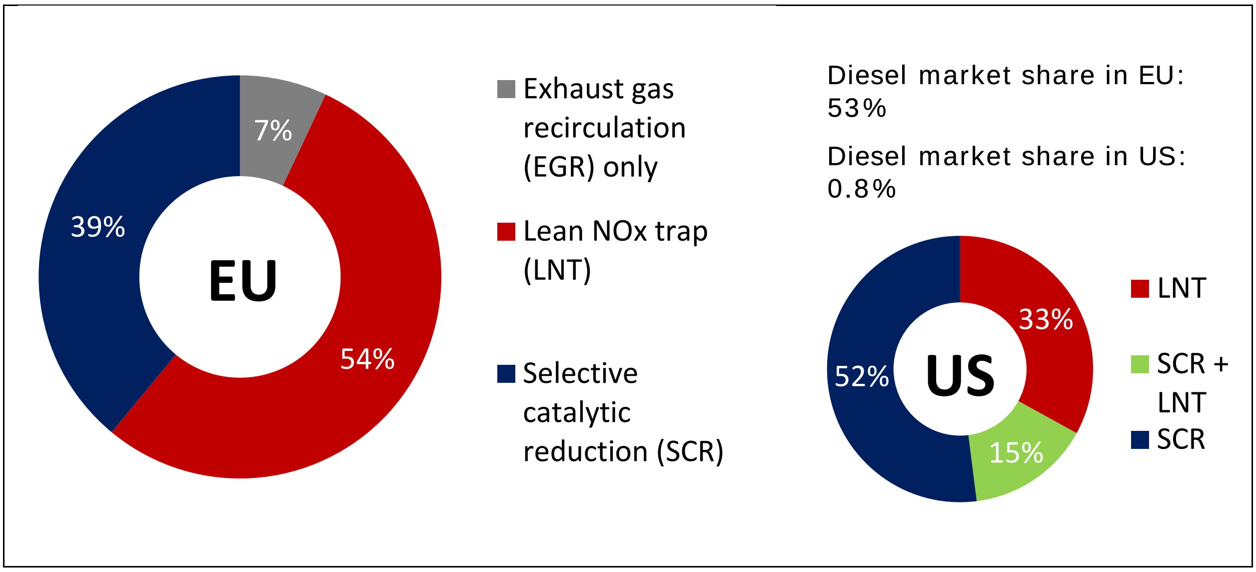
2.7.6. Recent developments

Increasingly, SCR and LNT technologies are combined in high-spec diesel cars (particularly for the US market) to take advantage of the best operating characteristics of both. SCR and particulate filter technologies are also being combined to provide better emissions performance. Inevitably such advanced options come at a cost, but this will surely fall quite quickly, and these advanced configurations will be deployed more widely.

2.8. The use of diesel abatement technologies in the EU and USA

Figure 2 from shows recent data published by the International Council for Clean Technologies (ICCT) on the mix of NOx abatement technologies in the US and EU for Euro 6-equivalent diesel cars in 2014.

Figure 2: Aplication of diesel de-NOx technologies in new cars in 2014



Source: ICCT 2014

This illustrates that the tighter standards and more advanced stage of implementation in the US have brought about a very different mix of technologies from that found in the EU. That is, SCR was by 2014 fitted to two thirds of all new diesel sold in the US, in some cases in combination with LNT. In contrast, LNT was the principal technology on only one third of the cars sold, and it is very likely that this proportion will have fallen further since, not least on account of the closer scrutiny resulting from the Volkswagen scandal.

It should be stressed however that the two markets are very dissimilar. In the EU, diesels account for more than half of all new car sales and have done so for several years, and most major manufacturers sell a substantial number of diesel models. In the US, in contrast, diesels remain a niche market accounting for less than 1% of new cars sold, and more than 90% of these are made by the main German brands (VW and Audi, BMW and Mercedes).

Recent analysis by T&E for its ‘dirty diesels’ report showed some improvement in the proportion of Euro 6 diesels failing a range of ‘real world’ tests relative to Euro 5, but the numbers remained high in 2015. The data also showed that diesels with SCR generally performed significantly better than those with only EGR or LNT.

Both recent events and the impending introduction of the RDE test in Europe suggest that the mix of new technologies in Europe will now move in the same direction of those in the US – that is, for a steady growth in the application of SCR technology, sometimes in combination with LNT.

3. SYSTEMS FOR TYPE APPROVAL, CONFORMITY OF PRODUCTION, AND IN-SERVICE PERFORMANCE IN THE EU AND THE US

3.1. Comparison of approaches to type approval and vehicle performance in the EU and the US

Both in the US and in the EU, in order to secure approval to be placed on the market, new vehicle models have to go through a test procedure in which the car's features, performance and emissions are analysed to ensure compliance with regulatory standards. Both systems then aim to further ensure that individual examples of these vehicle models comply with the relevant standards through conformity of production (COP) procedures.

The broad approach to ensuring that vehicles placed on the market comply with emissions standards is essentially similar in the EU and the US: standardized processes and standardized determination of data to ensure legal compliance. However, the development of and rationale for the two systems shows some important differences, which in turn contribute to significant differences in effectiveness, as detailed in later sections of this report. In the EU, legislation at the European level followed the development of type approval systems in the original Member States, and was initially aimed at ensuring that type approval systems at national level were not used as a means of protecting a Member State's own manufacturers, and did not incidentally have the effect of damaging the development of the internal marketsystems. This led to a system of mutual recognition of national type approvals and of the national type approval authorities, but with little or no central oversight – what was to become a key weakness of the EU system. Systems in the US, by contrast, appear to have been less concerned with the management of inter-state commerce and more directly concerned with the effective enforcement of the relevant standards.

Thus, while the broad design of the system is similar, the approval processes and underlying test cycles differ in terms of the authorities responsible, and the test cycles used for determining compliance with emissions standards. In the US the EPA is responsible for all decisions on the conformity of vehicle models with emissions standards. The EPA also has responsibility for the monitoring of vehicle emissions in use, and deploys mandatory testing of vehicles – an issue dealt with in more detail in section 3.7 below. In the EU, however, detailed implementation is left in the hands of the individual Member States, with limited oversight by the European Commission with regard to how, in practice, the standards are applied, and very little in-use monitoring. Moreover, environmental agencies with a direct responsibility for the air quality and greenhouse gas outcomes that the legislation is designed to achieve have, in most Member States, little or no role in monitoring the effectiveness of implementation through the type approval process.

In relation to the test cycles, while in the EU, the New European Drive Cycle (NEDC) is currently applied, the US uses the Federal Test Procedure (FTP). There are significant differences between the two test procedures (in respect of speed, duration, engine conditions, etc.), which are addressed in more detail in sections 3.8 and 3.9 below.

In addition, there are significant differences in checking compliance. While in the EU, emissions are only measured during the type-approval process, in the US, as noted above, additional surveillance testing and random checks apply when the vehicle is in-service. Hence, the stringency of emission standards in the EU and in the US is not always directly comparable, with the US system benefiting from a number of additional elements (such as enhanced surveillance and in-service monitoring; stricter requirements on transparency of the use of emissions control technologies and "defeat devices") aimed at ensuring that the intentions behind legislation in terms of reductions in emissions are delivered more effectively in practice. The following sections provide detail on the systems in the EU and in the US.

3.2. Type approval in the EU

Type approval is the process applied by Member State authorities to certify that a model of a certain vehicle (or a vehicle type) meets all EU safety, environmental and production requirements before authorising it to be placed on the EU market. It focuses on pre-market compliance checks of vehicles, on the basis of testing a sample vehicle.

Type approval is subject to single market legislation, and to detailed implementing legislation defining the test procedures, which are kept under review by the Commission's Technical Committee for Motor Vehicles (TCMV), on which all Members States are represented. The EU type-approval system is based on the principle of third-party approvals and mutual recognition of such approvals. The system places specific obligations on manufacturers, and among other things ensures access to repair and maintenance information.

Significant changes to the type approval system, including a number which aim to respond to concerns about the effectiveness of the system raised by stakeholders and detailed in this report, have been proposed by the Commission, and are currently under consideration by the co-legislators[50]. The Commission's proposal in particular includes harmonisation and strengthening of the type-approval and conformity of production procedures; and measures to address potential conflicts of interest and misaligned incentives in the current system, including through a restructuring of the basis for the payment of fees for type approval, and a clarification of the respective roles and responsibilities of manufactuers and type approval authorities. In addition, it includes proposals for a new system of market surveillance, aimed at addressing weaknesses in the identification and follow-up of discrepancies between emissions assessed at type approval, and the subsequent performance of vehicles in use. A detailed assessment of the proposals is beyond the scope of this report, although we include some observations on them in the Conclusions and Policy Outlook (section 8). The description that follows is of the type approval system as it exists currently.

As it is not practical to test every single vehicle made, for example for exhaust emissions, one production vehicle is tested as being representative of the 'type', that may encompass a number of different variants with similar characteristics such as engine size and type. Alternatively, and in agreement with the type-approval authority, the manufacturers ("Original Equipment Manufacturers" or OEM) may select a vehicle that "combines a number of the most unfavourable features with regards to the required level of performance"[51]. A number of performance requirements will apply to a given vehicle type ranging from tyres through to exhaust emissions and braking systems[52].

For CO_2, however, the manufacturer will usually not test only one vehicle of a type, as every gramme counts for the manufacturer's fleet average value. Therefore, the manufacturer will test each variant separately to achieve the lowest possible CO_2 emission average. Tests for exhaust emissions and CO_2 can be carried out separately, i.e. the OEM is free to choose

[50] COM/2016/031 final - 2016/014 (COD): Proposal for a Regulation of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.

[51] Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles. Available: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32007L0046

[52] UK Government, Department for Transport, European Community Whole Vehicle Type Approval (ECWVTA) http://www.dft.gov.uk/vca/vehicletype/ecwvta-framework-directive.asp

different vehicles for each test.[53] Vehicle manufacturers are not bound to a specific type-approval authority, as approvals obtained in any Member State for a component, system, or whole vehicle are recognized by other Member States. It can choose a Member State, and thereby a type-approval authority, that suits it best.

As a number of observers have pointed out, this system provides significant flexibility to manfacturers to choose its regulator. As the International Council for Clean Transportation has pointed out, it is not unusual for a manufacturer, to obtain type-approval for the fuel consumption and exhaust pollutant emissions of a vehicle in Luxembourg but the final Whole Vehicle Type Approval (WVTA) in Germany[54,55]. While the current project has not investigated the rationale for manufacturers choosing different type approval authorities for different purposes, it is reasonable to assume that perceived stringency of enforcement of the relevant standards plays a part in the decision. At a minimum, it appears unlikely to foster public confidence in the rigour of the overall EU type approval system.

As detailed in an analysis[56] commissioned by the European Parliament's EMIS committee, the type-approval process consists of the following steps:

- OEM's application for type approval & initial Conformity of Production (CoP) assessment
- Testing process
- Submission of documents
- Granting of the EC WVTA & concluding CoP arrangements
- Vehicle registration & continued CoP verification
- In-service conformity (ISC).

Further, the type-approval process consists of various types of approval, including approval for individual components (such as headlamps, mirrors, tires), system approvals (for example, brake system, exhaust pollutant emissions, etc.), and then finally Whole Vehicle Type-Approval (WVTA)[57].

When the design process for a new vehicle model is started, target values for fuel consumption and emissions are usually set by manufacturers based on experience and computer simulations. The responsible type-approval engineer will oversee the testing process, and once targets are reached, the emissions values for that vehicle are declared.

For CO_2, if the value measured during this final test does not exceed the declared value by more than 4%, the declared value then becomes the official type-approval figure for that

53 Commission Directive 93/116/EC of 17 December 1993 adapting to technical progress Council Directive 80/1268/EEC relating to the fuel consumption of motor vehicles. Available: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31993L0116

54 The International Council on Clean Transportation (ICCT), The Future of Vehicle Emissions Testing and Compliance http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf, Nov 2015

55 ICCT blog http://www.theicct.org/blogs/staff/future-vehicle-emissions-testing-europe-and-beyond

56 Heinfellner, H., Konrad, C., Lichtblau, G., Schodl, B., Stranner, G., Winter, R., *Legal obligations relating to emission measurements in the EU automotice sector*, Study for the EMIS Committee, 2016, European Parliament Directorate General for Internal Policies, Policy department A, Brussels, available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/578996/IPOL_STU(2016)578996_EN.pdf

57 The International Council on Clean Transportation (ICCT), The Future of Vehicle Emissions Testing and Compliance http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf, Nov 2015

vehicle type. In practice, according to the ICCT, this flexibility has led to a situation in which the manufacturer routinely deducts 4 percent of a vehicle's CO_2 test result[58].

An important factor for the realistic assessment of fuel consumption and CO_2 emissions of a vehicle in a chassis dynamometer test (as part of the type-approval process) is the determination of the road load coefficient from coast down testing[59], a process for measuring vehicle resistance as a function of speed by allowing it to coast in neutral from a specified speed. As coast-down tests are expensive, manufacturers may reduce the number of tests by choosing only to test a worst case variant. In the EU, coast down tests are treated as competitive information and not made available to the public. As a result, the tests themselves are not open to scrutiny, and without the coast-down results it is impossible for a third party to replicate or check the laboratory tests undertaked in type approval.

Each EU Member State has its own designated type-approval authority - examples include the Kraftfahrt-Bundesamt (KBA) in Germany, the Centre National de Réception des Véhicules, under the aegis of the Ile de France regional directorate of the Environment and Energy ministry in France, and the Vehicle Certification Agency (VCA) in the United Kingdom – with a range of tutelary ministries at national level, but most commonly the Ministry of Transport or equivalent (as in the case of the German and UK examples mentioned above). While the duties that the type-approval authority must fulfil are laid down in the European legislation, the way in which the authorities are structured, including their funding, vary significantly between Member States.

The number of technical services companies appointed by type-approval authorities to carry out tests vary between MemberMember StateStates with e.g. over 80 services listed in Germany and only one technical service company (UTAC) in France. In the UK, a striking aspect of the system is that the VCA also offers its own services as one of the technical service companies, creating at least the perception of a potential conflict of interest in its accreditation of technical service comparnies. Annex 1 provides a case study of how the type approval system operates in one Member State.

3.3. Equivalents to type approval in the US

Type approval, in the form that is required in the EU, does not exist in the US system. The EPA specifies a set of standards, categorised according to vehicle type/weight or by manufacturer selection, which must be adhered to in order for their vehicles to reach the marketplace.

The EPA administers a certification programme, through various stages of testing (see Figure 3), to ensure that every vehicle introduced to market complies with emission standards, with an approach based on certificates of conformity rather than a prior type approval process. The manufacturer must present adequate proof of conformity to gain a Certificate of Conformity from EPA[60]. In addition to this, all certified vehicles and engines are required by the Clean Air Act to have emissions labels[61].

The certification process requires a manufacturer to apply for certification by the EPA for groups of vehicles or engines having similar design and emission characteristics. The

[58] The International Council on Clean Transportation (ICCT), The Future of Vehicle Emissions Testing and Compliance http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf, Nov 2015

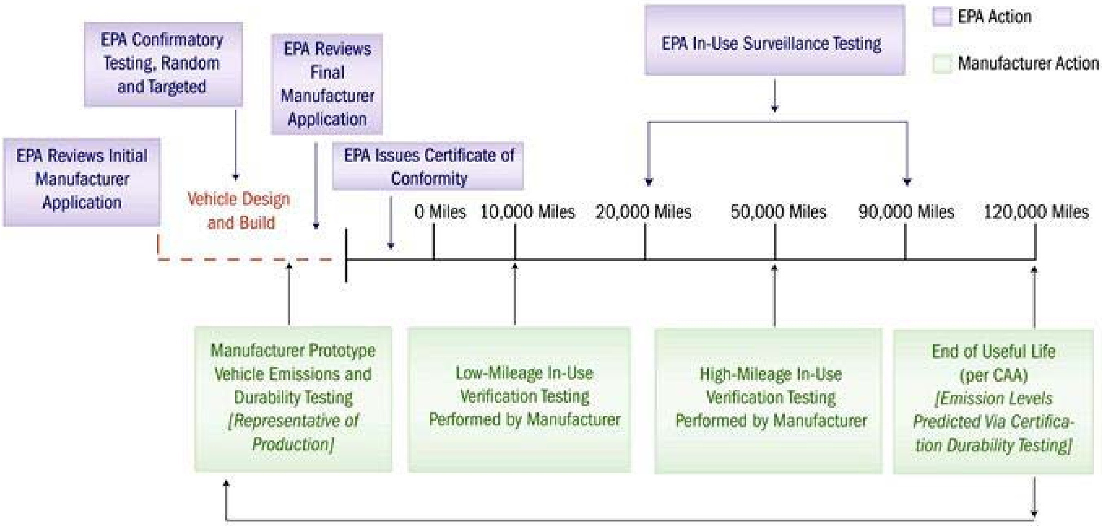
[59] Details on the measurement procedure of vehicle road load can be found in Annex 4a — Appendix 7 of UNECE regulation No. 83.

[60] The USEPA Emissions Standards Reference Guide https://www.epa.gov/emission-standards-reference-guide/learn-about-emission-standards-reference-guide-road-and-nonroad

[61] The USEPA Enforcement Regulation, Air Enforcement https://www.epa.gov/enforcement/air-enforcement#engines

manufacturer is obliged to provide comprehensive information to show that they have met all of the applicable requirements, including, as noted in the section on defeat devices below, a detailed account of the presence of any auxiliary emissions control devices (AECDs). The EPA's emission regulations specify the relevant test procedures to measure engine or vehicle emission levels, with the number and types of tests varying according to the type of vehicle.

Figure 3: A flowchart to describe the compliance life of a light-duty vehicle



Source: United States Environment Protection Agency (EPA)

3.4. Conformity of production in the EU

Conformity of production (in agreement with the approval authority) is part of the type approval process as outlined in the relevant EC Directive 2007/46/EC and its Annex IV (see previous chapter on type-approval).

The manufacturer has the responsibility to ensure the conformity of production to the approved type[62]. For a manufacturer to obtain and maintain the CoP certificate throughout the production phase of a vehicle, it must demonstrate that each vehicle is manufactured in accordance with the approved specifications.

In practice in the EU, it is often sufficient for the manufacturer to demonstrate that it has a stringent quality-management system (for example, meeting the ISO 9001 standard) in place.

The EU regulations also require the manufacturer to test emissions from vehicles randomly chosen from the assembly line. For CO_2, the emission value found by the manufacturer during this in-production test is allowed to be at most 8 percent higher than the type-approval CO_2 figure (which, as noted above, itself benefits from a 4% flexibility in type approval testing). The manufacturer is required to present the test results to the corresponding type-approval authority. Independent tests performed by a third party other than the type-approval authority are not foreseen by EU regulations[63].

[62] EUR-lex, European Union law http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3An26100

[63] The International Council on Clean Transportation (ICCT), The Future of Vehicle Emissions Testing and Compliance http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf, Nov 2015

3.5. Conformity of production in the US

The certificates of conformity of production referred to in section 3.3 above are issued to demonstrate that each vehicle manufactured has been built in such a way that the relevant standards are met. In the US, applications to obtain such a certificate require three components[64]:

1. A description of the vehicle or engine that is to be approved with specifics about the engine itself, the emission control systems and fuel components;
2. A detailed description of any Auxiliary Emission Control Devises (AECD) that may be installed; and
3. A detailed explanation as to why each AECD, if any, is to be installed that might reduce the efficacy of the vehicle's emission control systems.

3.6. In-service performance verification in the EU

The following paragraphs describe the current system of in-service performance verification in the EU, and as developed by individual Member States.

The required vehicle testing is carried out exclusively in the laboratory, in accordance with the New European Driving Cycle (NEDC). There is no testing under real-world driving conditions, notwithstanding the example of the far more detailed and realistic testing of heavy duty vehicles, including portable emissions measurement system (PEMS) testing, and none of the data referring to the in-service conformity process is made public. It is the manufacturers who commission the testing from approved test centres, with no independent re-testing by regulators at national or European level[65].

Manufacturers are obliged under Regulation 715/2007[66] to "ensure that type approval procedures for verifying conformity of production, durability of pollution control devices and in-service conformity are met", and to take technical measures "such as to ensure that the tailpipe and evaporative emissions are effectively limited, pursuant to this Regulation, throughout the normal life of the vehicles under normal conditions of use". Commission regulation 692/2008 further specifies that (except for vehicles manufactured in small series) "the in-service conformity measures shall be checked for a period of up to 5 years of age or 100 000 km, whichever is the sooner". The legislation goes on to specify[67] the requirements for selecting vehicles for testing, the testing to be carried out, the process for auditing of in-service conformity by the relevant type approval authority, and the requirement for a plan of remedial mesures if more than one tested vehicle shows discrepancies. However, it is unclear how effectively these provisions are implemented, or even how manufacturers and type approval authorities are interpreting them, since, critically, there is no requirement to make data public (either in respect of the results of conformity testing, or even the number of vehicles tested). We have not been able to identify examples of a plan of remedial measures.

While it is open to Member States to run their own market surveillance programmes – and, arguably, necessary in order to comply with their responsibility to ensure that type approval and emissions legislation is complied with – in practice there has been limited enthusiasm

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[64] Transport and Environment (2016) 'Comparison of EU and US defeat device legislation: Suggestion on how EU type approval and Euro 6 laws can be strengthened' (link??)

[65] The International Council on Clean Transportation (ICCT), The Future of Vehicle Emissions Testing and Compliance http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf, Nov 2015

[66] See article 4 (2).

[67] See Annex XV

for doing so, and most programmes that were in existence have been discontinued; although the Swedish Transport Agency appears to still run a regular programme, the latest available report for light vehicles dates from 2013[68]. The programme is carried out by the Swedish Transport Agency in conjunction with Swedac and the Ministry of Enterprise, Energy and Communications. This taskforce is responsible for ensuring that the "market works well with respect to road safety, environment, price trend, technical development and accessibility"[69]. In response to the VW scandal in the US, a number of Member States and type approval authorities have initiated ad hoc investigations. The German investigation is presented in detail in Box 1 in section 4.4 below, and involved 56 tests on 53 models of (Euro 5 and Euro 6) vehicles. Details of programmes in the UK, France, and Italy are set out below.

The UK programme tested 19 Euro 6 models, and 18 Euro 5 models, and involved testing on the NEDC cycle used for type approval, and an on road Real Driving Emissions test. While only vehicles from the Volkswagen group (in this case, a Skoda model identified by Voklswagen as incorporating the technology) showed clear evidence of test cycle recognition devices, significantly high NOx emissions – on average 1135 mg/km, around 6 times in excess of the type approval limit value of 180 mg/km for Euro 5, and on average 500 mg/km for Euro 6 vehicles, compared to the type approval limit of 80 mg/km - were detected from the RDE tests. The report also raises questions about the use of temperature recognition devices to control Exhaust Gas Recirculation (EGR); although it notes some evidence to support manufacturers' arguments that this is necessary to ensure that the emissions control works reliably during normal vehicle use and over the extended conditions of 100,000 miles. It draw the conclusion that significantly greater transparency is required in the type approval system, with manufacturers required to "declare the presence of any aspect of the emissions control system (for example the EGR control strategy) which might reduce its effectiveness during real world use".

The French programme involved a smilar range of tests, aimed at replicating the NEDC cycle, and comparing it with an adjusted test cycle, and with emissions measured by PEMs in the RDE test cycle. A total of 86 models were tested. Again, significantly higher NOx values were obtained from the RDE tests, 10 times higher than the type approval limit for some models, as well as less dramatic, but still significant, exceedances in CO_2 emissions for the majority of vehicles. The committee of inquiry concludes that defeat devices are present, while noting the explanations of manufacturers that these devices are justified under the permitted derogations, in particular in order to preserve reliability and performance. The committee also reaches the conclusion that significantly greater transparency needs to be demanded of manufacturers, with a compulsory declaration of all such technologies and their justification.

The Italian Ministry of Transport has also established a programme of tests on emissions from diesel vehicles. The test campaign started formally in January 2016, and is understood also to include a mix of lab tests and road tests, covering more than 30 models. A Ministerial Decree was approved on 26th February 2016 with the aim of setting the procedure and the timeline for the test programme. On 3rd August 2016, a public call for tender to undertake tests of new and circulating vehicles was launched with a deadline for applications of 18th October 2016. It is not clear when results from the programme will be made available.

However, these test programmes are all ad hoc, and specific response to the VW scandal. The lack of Member State enthusiasm for regular market surveillance programmes has a

68 Swedish In-Service Testing Programme on Emissions from Passenger Cars and Light-Duty Trucks: Annual Report 2013, at http://www.transportstyrelsen.se/globalassets/global/vag/miljo/latta-fordon-2013.pdf

69 Swedish Transport Agency 'Market supervision of the vehicle inspection market' http://transportstyrelsen.se/en/road/Market-Studies-/

number of possible causes, as set out in an earlier study for the European Parliament[70]; in particular the potential cost, the costs involved in pursuing discrepancies through court action, and the potential difficulty in persuading other type approval authorities to take action in respect of vehicles for which they are responsible. We comment in later sections of the report on the lack of alignment of incentives of transport and type approval authorities in Member States, which, unlike the EPA in the US, do not have a primary objective of environmental and human health protection.

3.7. In-service performance verification in the US

As shown by Figure 3, in-service testing is carried out by the manufactueres after around 10,000 miles and 50,000 miles as well as by the EPA after 20,000 miles and again after 90,000 miles to ensure that vehicles and engines are meeting the in-use standards. In addition to this surveillance testing, inspection and maintenance programs are implemented at the state level and on-board diagnostic systems are used to alert the driver of any malfunctions of the mechanisms installed to reduce emissions and remain compliant. It is a legal requirement that light-duty vehicles include such systems[71].

If it is discovered that a “substantial number of vehicles of engines in a category or class” are not meeting the relevant emissions standards, manufacturers are required to issue a recall of the failing vehicles. They are then expected to fix any issues that are causing said vehicles to fail emissions tests[72].

3.8. Testing regimes in the EU

Emission test cycles are a key element in the legislation. As mentioned above, in the EU, the basis for the vehicle testing process is the New European Driving Cycle (NEDC).

The NEDC was introduced in the 1960s and 1970s, at a time when vehicle CO_2 emissions were not tested and did not have any impact on a vehicle manufacturer’s economic performance. Updated in 1990, the NEDC now involves a speed pattern with low acceleration, constant speed (totalling 38.8% of the cycle) and idling periods (totalling 20.4% of the cycle) which are aimed at replicating a range of driving patterns e.g. in urban and rural areas, but which typically under-load modern engines[73].

The test cycle assumes moderate ambient temperatures and no application of heating or cooling systems – while this is a simplification in order to standardize values across the EU, the actual performance of the vehicle might substantially deviate from the measured performance – also with regards to different driving patterns in different EU countries and varying regulations, e.g. with regards to speed limits. The NEDC is shown in Figure 4, and is characterised by gentle and steady accelerations, with short periods of steady-state driving and equally gentle decelerations, interspersed with considerable stationary intervals.

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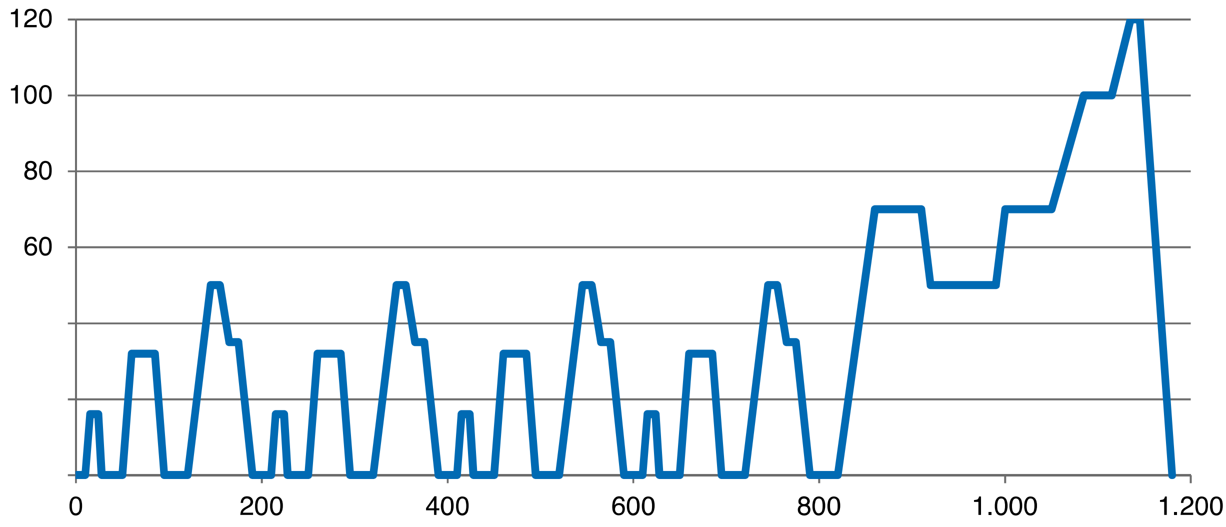
[70] EP, Directorate General for Internal Policies, Policy department A, Legal Obligations relating to emission measurements in the EU automotive industry, 2016 http://www.europarl.europa.eu/RegData/etudes/STUD/2016/578996/IPOL_STU(2016)578996_EN.pdf

[71] The US EPA, The Clean Air Act in a Nutshell: How it Works https://www.epa.gov/sites/production/files/2015-05/documents/caa_nutshell.pdf

[72] The US EPA. 2009-2011 Compliance Report & Compliance Activities https://www3.epa.gov/otaq/documents/cert/420r13006.pdf

[73] EP Briefing, Motor vehicles: new approval and market surveillance rules, Feb 2016 http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/481375/EPRS_BRI(2016)481375_EN.pdf

Figure 4: New European Drive Cycle (Speed in Km/h, time in s)



Source: ICCT (2014)[74]

There is wide agreement that the NEDC is outdated, and is one of the causes for the gap between real-world and laboratory test emissions. It includes a number of tolerances and flexibilities, which in practice manufacturers were likely to exploit to their advantage, and it no longer accurately reflects state-of-the-art technologies or typical driving patterns. Therefore, the European Union (EU) is planning to replace it with the newly developed Worldwide harmonized Light Vehicles Test Procedure (WLTP) in 2017. The WLTP was developed under the UNECE and, compared to the current NEDC (New European Drive Cycle), better reflects the reality of everyday driving[75].Figure 5 below displays the differences between NEDC and WLTP test cycles[76].

Figure 5: Differences between NEDC and the WLTP Test Cycle

	Unit	NEDC	WLTC
Duration of cycle	[sec]	1 180	1 800
Length of cycle	[km]	11.03	23.27
Average speed	[km/h]	33.6	46.5
Maximum speed	[km/h]	120.0	131.3
Neutral share	[%]	23.7	12.6
Constant drive share	[%]	40.3	3.7
Acceleration share	[%]	20.9	43.8
Deceleration share	[%]	15.1	39.9

Source: ICCT (2014)

[74] ICCT Working Paper (2014) 'Development of test cycle conversion factors among worldwide light duty vehicle CO_2 emission standards'

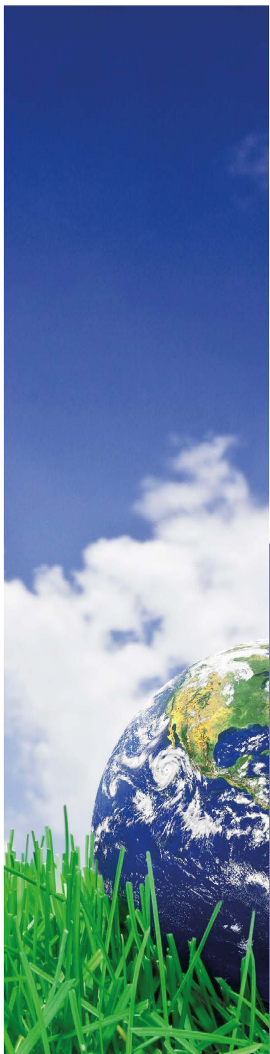
[75] ICCT Working Paper, The WLTP: How a new test procedure for cars will affect fuel consumption values in the EU http://www.theicct.org/sites/default/files/publications/ICCT_WLTP_EffectEU_20141029.pdf, Oct 2014

[76] EP, Directorate General for Internal Policies, Policy department A, Legal Obligations relating to emission measurements in the EU automotive industry, 2016 http://www.europarl.europa.eu/RegData/etudes/STUD/2016/578996/IPOL_STU(2016)578996_EN.pdf

European Parliament

DIRECTORATE-GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT A
ECONOMIC AND SCIENTIFIC POLICY



Economic and Monetary Affairs

Employment and Social Affairs

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Internal Market and Consumer Protection

Comparative Study on the Differences between the EU and US Legislation on Emissions in the Automotive Sector

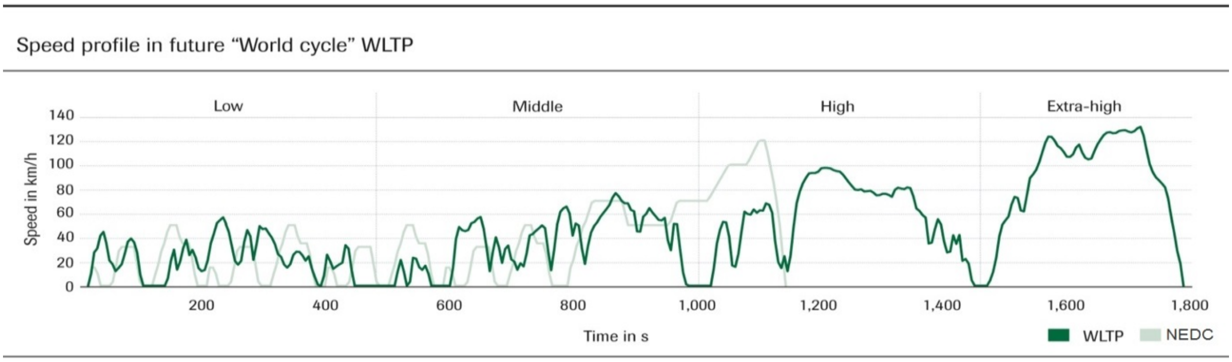
STUDY for the ENVI Committee

EN

2016

Figure 6 illustrates the different speed profiles in the NEDC and WLTP test cycles[77].

Figure 6: Speed profile in future World Cycle WLTP compared to NEDC



Source: UNECE

As part of the WLTP implementation, the CO_2 targets defined for 2020-2021 based on NEDC testing will need to be translated to WLTP equivalent values. While the introduction of WLTP for the measurement of gaseous pollutants and particles is quite straightforward (same emission limits as with NEDC), the replacement of NEDC in the CO_2 regulations is more complex. Reasons are connected with the constraints set by the Commission to ensure comparability between manufacturers and vehicles of different utility.

Scientific research shows discrepancies between CO_2 impact under NEDC and WLTP. Generally, CO_2 emissions under WLTP are higher than under NEDC, and Diesel vehicles are more impacted than petrol-fuelled vehicles by the change from NEDC to WLTP.

In order to fully implement WLTP, the following phased approach is foreseen:

Up to August 2017:

- NEDC testing will remain in place
- Vehicle manufacturers will prepare for WLTP and in some cases already begin to publish WLTP figures for new models

September 2017 to December 2019:

- WLTP type approval testing will be introduced for new vehicles
- New vehicles will be tested both using both NEDC and WLTP type approval procedures
- The legally binding values for the CO_2 monitoring will remain the NEDC based results
- WLTP based results can be used for customer information (sales brochures and CO_2 labelling)
- As further focus is placed on WLTP results by various stakeholders it is expected that national tax regulations will adapt to utilising WLTP based CO_2 values. Correspondingly vehicle manufacturers will optimise vehicle development for this test rather than NEDC.

From 2020 onwards:

[77] VDA (Verband der Automobilindustrie Germany), Exhaust emissions https://www.vda.de/en/topics/environment-and-climate/exhaust-emissions/fuel-consumption-in-nedc.html

- New vehicles will be tested using WLTP type approval procedure only
- CO_2 emission targets will have to be met on the basis of emissions measured under the WLTP
- For this, it is necessary to translate the existing 95 g/km NEDC based target into an equivalent WLTP based target (expected to be about 100g/km)
- To allow sufficient time for vehicle manufacturers to adapt to WLTP, a further 12 months phase-in period will also come into place meaning that the 5% of vehicles with the highest CO_2 emission levels will not be counted in 2020 when determining whether a manufacturer met its target or not.

A further change in the short term which is expected to reduce the existing level of discrepancy for CO_2 and NOx emissions, in particular NOx from diesel cars, is the introduction of a Real Driving Emissions from light-duty vehicles (RDE) procedure. This was approved by national experts in the technical committee in 2015, and came into use (in an experimental phase) in January 2016. The relevant (Euro 6) legislation has since been amended through Commission Regulation 2016/427, and the RDE will have full legal force from late 2017 for new type approvals, and for all new cars from the following year.

This RDE procedure will add mandatory on-road testing using a Portable Emissions Measurement Systems (PEMS) mounted on a test vehicle on the road. These new requirements are additional to the current entirely laboratory-based test procedure and are intended as a supplementary test method to detect any gross deviations between test and on-road emissions, especially for diesel NOx. Initially the new limits will apply only to NOx, although they may later be extended to Particle Number limits. Rules are under development to ensure that the random real-world driving regime applied will be realistically representative of real world conditions, but without including any extreme driving such as excessive speeds or accelerations or abnormal driving conditions. This will evolve as the testing proceeds, and the requirements will then be implemented in a series of stages with full legal force.

The RDE will also involve setting a not-to-exceed (NTE) limit which will be defined through a Conformity Factor (CF), specifying by how much the RDE test results may exceed the original type approval test value. Critics have argued that the proposed CFs are too lax and will still allow real world emissions in excess of the limit values: however they should initially curb the worst excesses, and are expected to be tightened over time as both understanding and technology develop.

The RDE is is an important development, as it should serve to detect or eliminate at least gross deviations between emissions in the laboratory test and those in real-world conditions. There are two main reasons for this:

- Because this is an on-road test with a randomised drive cycle, it should be far more difficult to apply the sort of ‘defeat devices’ described above;
- Because the test is designed to more closely resemble real world conditions, it should ensure that ‘real’ emissions in a range of conditions cannot deviate too far from the type approval limit values as tested under the NEDC.

It should be noted that the RDE test is being incorporated into the type approval procedures. Thus it applies to new car models as type approved, but not to conformity in production or use.

3.9. Testing regimes in the US

The type and number of tests required by US legislation depend on the sectors in question but include:

- Pre-production testing to ensure all standards are met before granting approval
- Production evaluations ensure that the manufactures are building every-day vehicles that meet the standards (not simply just the test vehicles)
- In-use testing occurs several years after production to ensure that standards are being met across the life span of the vehicle.

As standards progressed and became more stringent, it was appropriate to ensure that the testing procedures used to assess vehicles were increasingly more representative of real world conditions such as cold engine starts, high-way driving, etc[78].

Federal Test Procedure

The Federal Test Procedure (FTP-75)[79] is the standard test used to determine the emission levels produced. It is considered one of the more complex testing cycles worldwide and is to reflect the typical driving style of the average American[80]. It consists of four different phases with a total duration of around 1877 seconds, distance of 11.04 miles, average speed of 21.2mph and a maximum speed of 56.7mph.

This testing regime consists of:

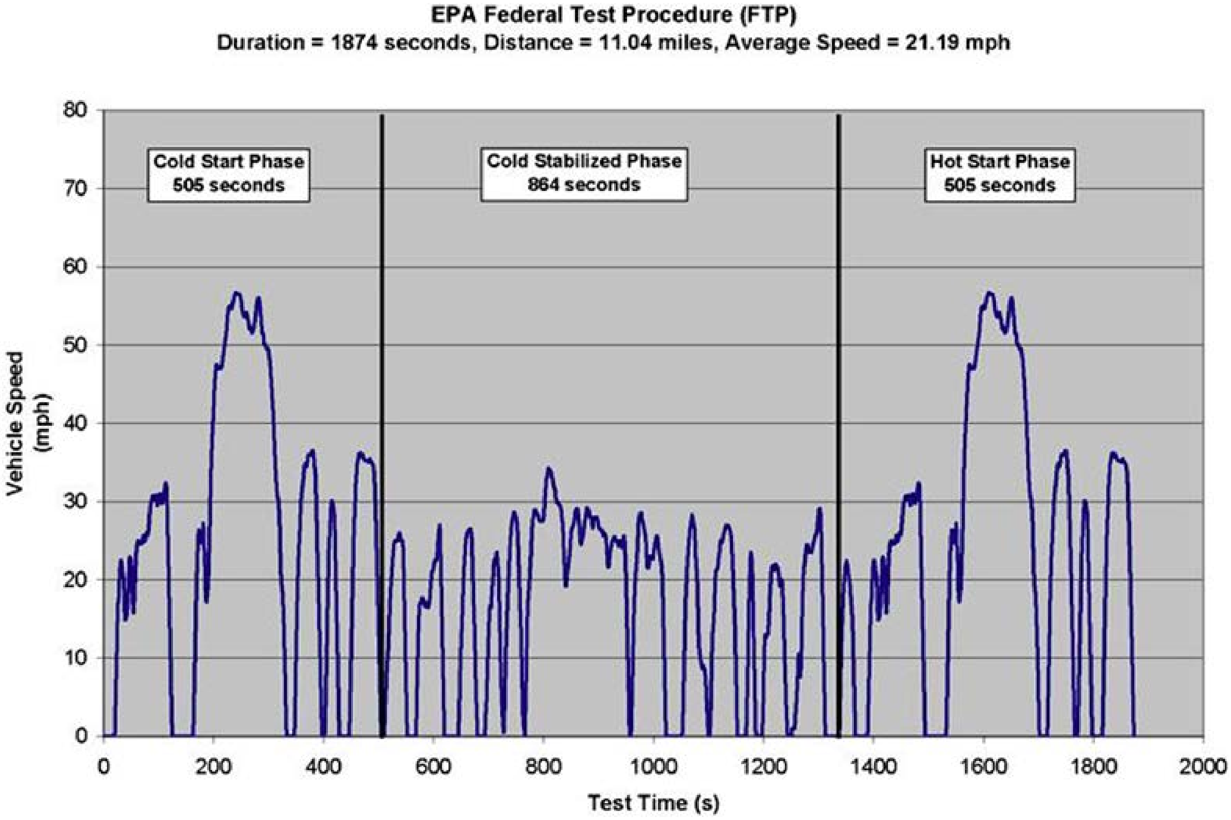
1. Cold start transient phase (ambient temperature 20-30°C): 0-505 seconds
2. Stabilized phase: 506-1372 seconds
3. Hot soak: min 540 seconds, max 660 seconds
4. Hot start transient phase: 0-505 seconds.

[78] Bielaczyc, P., Szczotka, A., Pajdowski, P., Woodburn, J. (2013), 'Development of automotive emissions testing equipment and test methods in response to legislative, technical and commercial requirements', *Combustion Engines*, 1(152).

[79] DieselNet Emission Test Cycle – FTP-75 https://www.dieselnet.com/standards/cycles/ftp75.php

[80] IW Köln (2013) ' CO_2-Regulierung für PKW: Fragen und Antworten zu den europäischen Grenzwerten für Fahrzeughersteller'

Figure 7: The US EPA's Federal Test Procedure Driving Cycle



Source: United States Environment Protection Agency (EPA)[81]

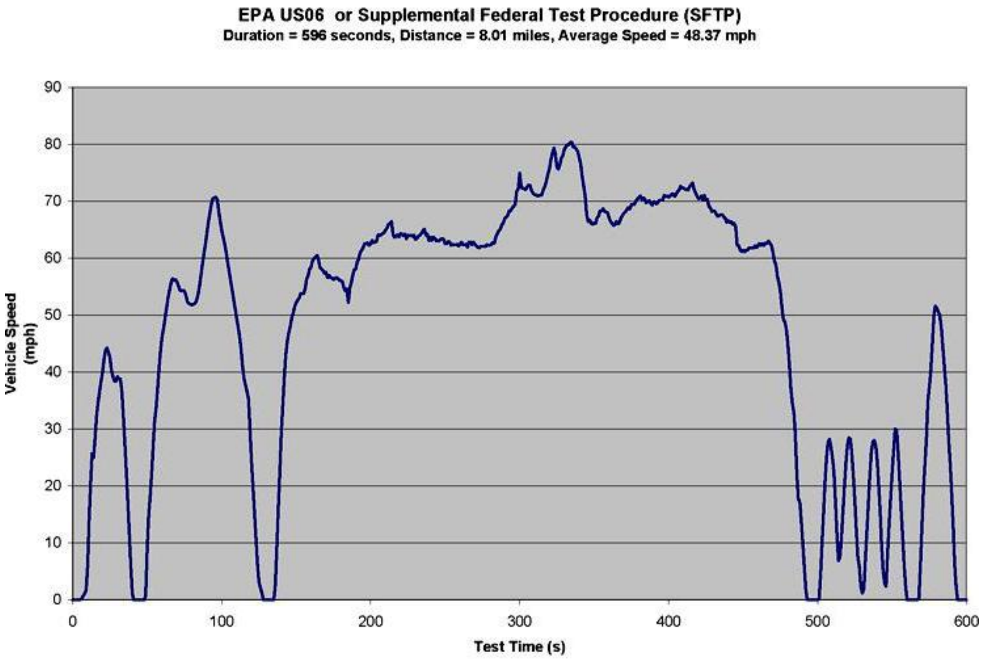
Supplemental Federal Test Procedure

The Supplemental Federal Test Procedure (SFTP) was introduced from Tier 2 onwards for use on models produced from 2000 onwards to make up for some shortcomings of the FTP cycle that was not a completely accurate reflection of real world driving. The SFTP comes with two additional tests:

1. US06 which represents 'aggressive, high speed driving' as might be seen as highway driving conditions (see Figure 8)
2. SC03 which mimics the use of air conditioning which has a big impact on the efficiency of vehicles (see Figure 9)

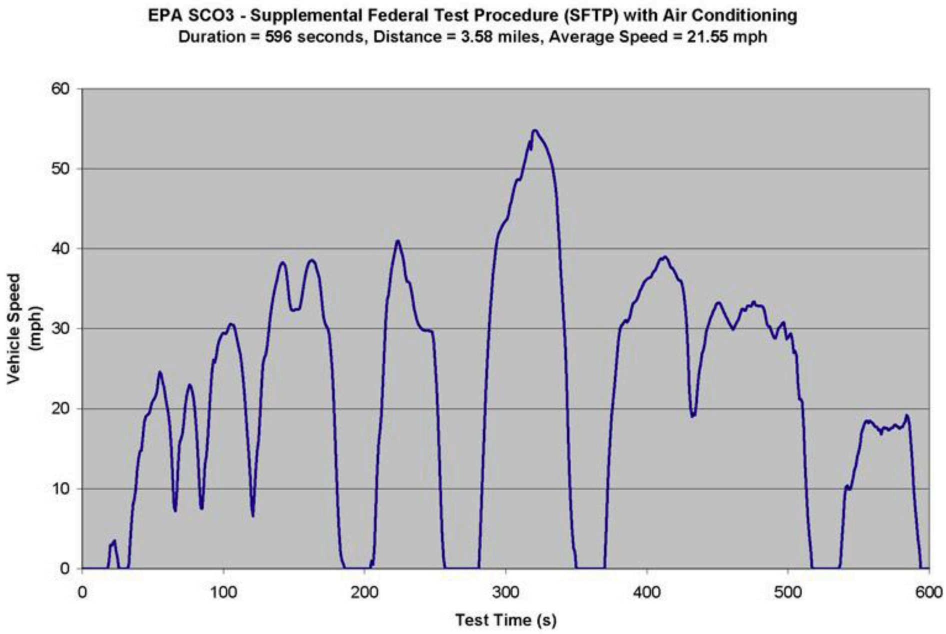
[81] USEPA's Emission Standards Reference Guide, SC03Federal Test CycleProcedure (FTP) https://www.epa.gov/emission-standards-reference-guide/epa-federal-test-procedure-ftp

Figure 8: The US EPA's Supplemental Federal Test Procedure (SFTP) US06



Source: United States Environment Protection Agency (EPA)[82]

Figure 9: The US EPA's Supplemental Federal Test Procedure (SFTP) SC03



Source: United Environment Protection Agency (EPA)[83]

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[82] US EPA's Emission Standards Reference Guide, US06 Test Cycle https:/www.epa.gov/emission-standards-reference-guide/epa-us06-or-supplemental-federal-test-procedure-sftp

[83] USEPA's Emission Standards Reference Guide, SC03 Test Cycle https://www.epa.gov/emission-standards-reference-guide/epa-sc03-supplemental-federal-test-procedure-sftp-air

The EPA also has a number of detailed testing procedures that they use to identify whether an AECD is present and legal. They "may test or require testing on any vehicle at a designated location, using driving cycles and conditions that may reasonably be expected to be encountered in normal operation and use for the purpose of investigating a potential defeat device."

The introduction of the"Worldwide Harmonized Light Vehicles Test Procedure" (WLTP) could in theory – if accepted by all affected countries – set a coherent approach to measuring pollutants and CO_2 emissions. However, US withdrawal from the process at an early stage, and lack of interest in adopting WLTP, limits the potential contribution of the new test procedure to comparability of standards; although its adoption in the EU will mean a greater degree of similarity between EU and US test regimes than at present.

4. IMPLEMENTATION AND ENFORCEMENT IN THE EU AND THE US

4.1. Comparison of EU and US approaches to implementation and enforcement

EU and US systems for the implementation and enforcement of standards differ significantly, as set out in the detailed descriptions below. In part, this reflects the different federal structures of the two jurisdictions, with the EU having a significantly looser system of Member State responsibility for the implementation of legislation, and no federal mechanism for direct delivery and enforcement. In practice, however, it appears that a number of additional elements contribute to greater effectiveness of the US system, in particular: (i) the EPA's mandate for protecting the environment and human health (as compared to the single market and transport policy origins of much of the enforcement machinery in the EU) and (ii) the EPA's greater experience of, and resources for, pursuing and enforcing cases of suspected infringement. In the EU, by contrast, recent experience suggests that there is a significant lack of clarity in practice as regards the responsibility for identifying, pursuing, and enforcing cases of infringement of the legislation.

4.2. Implementation in the EU

Stakeholders involved in the course of and after the type-approval process are the European Commission, EU Member States, type-approval authorities, technical services, as well as OEMs.

Manufacturers wishing to type approve vehicles for sale in Europe can choose whether to approve emissions to EC or to UNECE (United Nations Economic Commission for Europe) regulations. Details of the type-approval process are defined in a number of EU and UNECE regulations, a key one being Framework Directive 2007/46/EC[84].

As noted in section 3.2 above, vehicle manufacturers are not bound to a specific type-approval authority, as approvals obtained in any Member State for a component, system, or whole vehicle are recognized by other Member States. As the International Council on Clean Transportation has noted, "a manufacturer can choose any available technical service to test any of the specific regulatory requirements. It can get partial type-approvals in different Member States, but the overall type-approval must be delivered by one national authority"[85].

4.3. Implementation in the US

The standards set by the EPA are implemented on a national scale, except in California and in states adopting California's stricter standards; however, type approval and testing is the responsibility of the EPA in all US jurisdictions. This is ensured during various tests across different stages throughout the design and production process as well as the life span of the product. Tests are conducted at the EPA's National Vehicle and Fuel Emissions Laboratory (NVFEL), which is the case for a "portion of all new cars and trucks" to ensure production compliance as well as used cars to test in-use performance[86]. The process of testing vehicle

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[84] Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles. Available : http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32007L0046

[85] Briefing, Motor vehicles: new approval and market surveillance rules http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/481375/EPRS_BRI(2016)481375_EN.pdf, Feb 2016

[86] The USEPA, Certification and Compliance Testing: Vehicles https://www.epa.gov/vehicle-and-fuel-emissions-testing/certification-and-compliance-testing-vehicles

emissions is regulated in accordance with the Code of Federal Regulations (CFR)[87]. Manufacturers are accountable for ensuring that every vehicle or engine that they produce meets the applicable standards within the specified timeframe[88]. Similarly, stakeholders in the fuel industry must ensure that fuel standards, testing and reporting requirements are met[89].

States are also required to carry out the implementation of the regulation of the Clean Air Act so are required to play a major role in monitoring that emission standards are met. State Implementation Plans (SIPs) are submitted to the EPA for approval to ensure that they are meeting the minimum requirements of the Act. Plans include emissions inventories, emissions projections and computer models to estimate future air quality. Regarding automotive emissions specifically, SIPs also consider measures to reduce emissions from existing vehicles. These may include state emissions inspections and maintenance programs[90], in addition to federal enforcement of standards by the EPA. This requirement is analogous to the EU requirement on Member States to set out plans for meeting EU air quality requirements in agglomerations which currently exceed limit values.

The key distinction between the US system and the EU'sis the former's single authority with oversight of implementation and enforcement. The EPA is responsible for ensuring the conformity of all models with relevant emissions standards. Moreover, the EPA is also (in contrast to the majority of type approval authorities across the EU) a body with an explicit objective of protecting the environment and human health; and has a wider responsibility for delivering the overall ambition of US clean air legislation. It thus has both an unambiguous responsibility and authority to pursue suspected cases of infringement of the legislation, including malpractice on the part of manufacturers, but also a strong interest in ensuring the stringency of application of the legislation. This in turn may help to explain the EPA's introduction of significantly more ambitious mechanisms for in-service surveillance, with a commitment to follow-up and enforcement where discrepancies are identified.

4.4. Enforcement in the EU

In the EU, there is no independent EU-wide authority which validates in-use vehicles; this has led a number of stakeholders to conclude that there is no effective in-use compliance; and that the effectiveness of emissions legislation itself is therefore significantly reduced[91].

It is certainly the case that a manufacturer can choose what it perceives to be the most favourable technical service to test any of the specific regulatory requirements. It can apply for partial type-approvals in different Member States, although the overall type-approval must be delivered by one national authority. This offers obvious possibilities of 'shopping around' for the most favourable type approvel in each case.

Euro 6 regulations requiring cars to be tested under "normal driving conditions" were adopted in 2007 but the real-world driving emissions (RDE) tests in which portable emissions

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87 US GPO, 2016, 40 CFR Part 86 – Control of Emissions from new and in-use highway vehicles and engines http://www.ecfr.gov/cgi-bin/text-idx?SID=f4998116259c3d616115baa40e23648a&mc=true&node=pt40.19.86&rgn=div5#sp40.19.86.b

88 The USEPA Compliance Monitoring Programs – Mobile Source Compliance https://www.epa.gov/compliance/mobile-sources-compliance-monitoring-program

89 The USEPA Emissions Standards Referencing Guide https://www.epa.gov/emission-standards-reference-guide/learn-about-emission-standards-reference-guide-road-and-nonroad

90 The USEPA, The Clean Air Act in a Nutshell: How it Works https://www.epa.gov/sites/production/files/2015-05/documents/caa_nutshell.pdf

91 e.g. Transport & Environment, Mind the Gap, Sep 2015 https://www.transportenvironment.org/sites/te/files/publications/TE_Mind_the_Gap_2015_FINAL.pdf

monitoring systems (PEMS) measure the actual pollution emitted from the exhaust have still not commenced[92].

In 2016, following a long process of policy development, but also in response to the VW case, the European Commission proposed a strengthening of the type approval system for motor vehicles. Its goal is to ensure effective enforcement of rules (including through market surveillance), to strengthen the quality and independence of technical tests and to introduce EU oversight on the type-approval process[93].

Currently, the European Commission and legislators in the European Parliament have no oversight of the work of TAAs to ensure approvals are issued correctly, in accordance with EU law and to a consistently high standard. The Member State which grants type approval takes on the responsibility for pursuing evidence of discrepancies or misapplication of the legislation by OEMs[94]; which creates an incentive for the manufacturer to avoid type approval authorities which are perceived to be likely to take a strict line on in-use surveillance and the pursuit of discrepancies.

There are, moreover, a number of potential influences on type approval authorities which hinder or dissuade them from acting:

- The withdrawal of a type approval could be seen as an admission that it had failed to do its initial job properly
- A confrontational approach, including rigorous enforcement, would risk losing the business (and revenue) it receives from the manufacturer
- Many TAAs lack sufficient resources to undertake independent investigations, andlack the in-house legal expertise necessary to develop court action.

Box 1: Recent EU experience in relation to enforcement action

The VW case

On 18 September 2015 the US EPA served a Notice of Violation (NOV) on Volkswagen Group alleging that approximately 480,000 VW and Audi automobiles equipped with 2-litre TDI engines, and sold in the US between 2009 and 2015, had an emissions-compliance "defeat device" installed.

Following the findings against VW of the US Environment Protection Agency on 18th September 2015, the BMVI (Bundesministerium für Verkehr und digitale Infrastruktur, the German Transport Ministry) launched a Commission of Inquiry on the 22nd September 2015. The Commission had the mandate to investigate if unlawful test cycle defeat devices were being used in other vehicles. Federal Transport Minister Alexander Dobrindt called upon the KBA to conduct testing of German and foreign manufactured diesel vehicles commonly found on German roads. On this basis the KBA conducted 56 tests on 53 models of (Euro5 and Euro 6) vehicles.

In their investigations the KBA went beyond regulated testing procedure, and carried out the following eight tests on all 53 vehicle types:

Laboratory Tests - Dynamometer

1. Standard NEDC – cold start with pre-conditioning

[92] Transport & Environment, Don't breathe here https://www.transportenvironment.org/publications/dont-breathe-here-tackling-air-pollution-vehicles, 2014

[93] Briefing, Motor vehicles: new approval and market surveillance rules, Feb 2016 http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/481375/EPRS_BRI(2016)481375_EN.pdf

[94] Article 4 of directive 2007/46 states that «Member States shall ensure that manufacturers applying for approval comply with their obligations under this Directive.»

2. Same as Test 1, but with a warm engine without pre-conditioning

3. NEDC at low temperature (10 degrees)

On road Tests – Portable Emissions Measuring System (PEMS)

4. NEDC on the road with PEMS – using standard NEDC speed trace

5. NEDC backwards, Type 2 test (extra urban) followed by Type 1 (urban cycle)

6. NEDC with velocity increased by 10%

7. NEDC with velocity reduced by 10%

8. Real Driving Emissions (RDE) test procedure

Measurements conducted on VW Group vehicles with Euro 5 concepts (EA 189 engines) were able to show the effect of the unlawful defeat device.

The illegal defeat device recognises the statutory dynamometer test and ensures that the test is run in an emission reduction mode which leads to a significant reduction in NOx emissions. A switch to a different mode takes place on the road under comparable conditions so that NOx emissionsare abated to a much lesser degree.

Until the publication of this report, no illegal defeat device was found in any other vehicle than in certain VW Group vehicles. However, there was a broad range of the NOx emission values measured in the laboratory and on the road. All the manufacturers adjust the efficiency of their emission control system to driving conditions and environmental conditions. By any reasonable interpretation of the legal requirements, this appears to correspond to a defeat device according to the definition set out in Article 3 of the Regulation (EC) No. 715/2007.

The manufacturers justify the lawfulness mainly on the basis of the exemption clause in Article 5(2) of Regulation (EC) No. 715/2007 with measures aimed at protecting the engine or ensuring safe operation. For some vehicle types, however, the Commission of Inquiry of the BMVI has doubts regarding the lawfulness of the defeat device used.

The MAC case (Mobile air-conditioning Directive; Mercedes)

Another recent illustration of difficult legislation occurred in 2013 when Mercedes continued to use an illegal refrigerant in the air conditioning system of its cars despite it being outlawed in the EU. The type approval could have simply been withdrawn by the relevant national TAA, in this case the German KBA. But no such action was taken, leading the Commission to issue infringement proceedings against Germany[95].

The mechanism for enforcement of the CO_2 from cars regulation's fleet average emissions targets is more straightforward, since it does not require the identification of illegal activity, but relies on reported data on vehicles placed on the market. The legislation sets out[96] a system of fines which, for performance in the calendar years from 2012 to 2018, applies a sliding scale calculated on the basis of excess emissions multiplied by vehicles sold, with 5 EUR per vehicle for exceedances up to 1g/km, a further 15 EUR per vehicle for exceedances between 1g/km and 2g/km, a further 25 EUR per vehicle for exceedances between 2g/km

[95] See Commission press release of 10 December 2015 "Commission refers GERMANY to EU Court of Justice over the use of a banned greenhouse gas as car refrigerant"

[96] Article 9 (2) of Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO 2 emissions from light-duty vehicles. Available: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32009R0443

and 3g/km, and a further 95 EUR per vehicle for every further g/km of exceedance. From 2019, a flat rate fine of 95 EUR per vehicle per g/km of exceedance will be applied. Penalties for failure to comply with the type approval requirements in respect of the measurement of CO_2 emissions (for example, the use of illegal methods to falsify the measurement of emissions) are not set out in detail in the legislation, but rely on the standard text in the type approval directive for Member States to determine penalties which are “effective, proportionate and dissuasive”.

4.5. Enforcement in the US

Assessment of compliance takes place throughout the lifespan of the vehicle[97]. The EPA reviews applications for emissions certificates from vehicle and engine manufacturers, and conducts emissions testing of vehicles and engines both on the production line and then in-use following their introduction onto the market. Light-duty vehicles are checked periodically through state-implemented “inspection and maintenance” programs. The EPA also conducts inspections of:

- vehicle and engine manufacturing facilities,
- emission laboratories,
- dealers of vehicles and mobile engines and
- suppliers and installers of vehicle and engine parts

The EPA’s broad responsibility for ensuring compliance with the Clean Air Act includes the authority to take action, including court action, against manufacturers it considers to be in breach of the regulations. The EPA employs “information-gathering authorities” to identify implementation issues, and has the power to visit manufactures’ facilities, request documentation or conduct additional emissions testing.

The EPA can issue administrative penalities of up to $37,500 for every day that an administrative violation has taken place. There is a maximum penalty of $290,000, but this can be increased at the discretion of the Attorney General if they feel that the initial penalty is not fitting for the magnitude of the breach of the Act[98].

In addition to issuing administrative penalty orders, the EPA is authorised to issue civil penalties of up to

- $37 500 per noncompliant vehicle or engine
- $3 750 per tampering event (incl. defeat devices)
- $37,500 per day for violations pertaining to reporting or record keeping[99]

In cases of non-compliance with individual manufacturers’ obligations according to the EPA CO_2 regulations, no specific penalty-payment mechanisms applies. Instead, the vehicle is not approved and may not be sold. Noncompliance incurs fines of up to 38 000 USD per vehicle.

A recent example of enforcement of the standards used to regulate automotive emissions is that of the 2016 complaint against Volkswagen who sold some 600,000 diesel vehicles that did not meet the standards which therefore invalidated their Certificate of Conformity. To

[97] The US EPAUSEPA Compliance Monitoring Programs – Mobile Source Compliance https://www.epa.gov/compliance/mobile-sources-compliance-monitoring-program

[98] The US EPA, The Clean Air Act in a Nutshell: How it Works https://www.epa.gov/sites/production/files/2015-05/documents/caa_nutshell.pdf

[99] The US EPA, Clean Air Act Vehicle and Engine Enforcement Case Resolutions, https://www.epa.gov/enforcement/clean-air-act-vehicle-and-engine-enforcement-case-resolutions

date, courts have reached a partial settlement requiring the recall of at least 85% of these vehicles from the market by mid-2019, the payment of $2.7 billion to mitigate any issues caused by the additional NO_x emissions and allocation of $2 billion to the promotion of 'zero emission vehicles'[100]. There are many other examples of violations being penalised in efforts to enforce the emission regulations of the Clean Air Act.

[100] The US EPA, 'Volkswagen Clean Air Act Partial Settlement', https://www.epa.gov/enforcement/volkswagen-clean-air-act-partial-settlement#violations

5. IMPACT OF THE EFFECTIVENESS OF IMPLEMENTATION

5.1. Direct impacts in the EU

According to the European Commission, and a range of scientific sources, NOx emissions, and in particular NO_2 emissions, from road transport have not been reduced as much as expected with the introduction of the vehicle emissions standards since 1991, since emissions in real-life driving conditions are often higher than those measured during the approval test (in particular for diesel vehicles)[101]. The European Environment Agency, for example, stated already in a 2004 report on issues of concern to policymakers[102] that: "There is, however, increasing evidence that standardised test cycles used for the type approval of vehicles do not necessarily represent real world driving conditions", noting that this, in combination with increased road vehicle use, was likely to limit the chances of delivering air quality targets. Further, urban hotspots of high NO_2 concentrations are even more impacted by vehicle emissions, with the transport share rising to more than 60% as emissions from other sources are progressively reduced.

Essentially, EU car emission regulation, and clean air legislation more generally, appears to have been rendered less effective by weaknesses in the test procedure, and the extent to which manufacturers have been able to deliver apparent compliance without delivering the required reductions in vehicle emissions in use.[103] Two studies on emissions of air pollutants carried out in 2013 – one for the Dutch Government and another by the Commission's Joint Research Centre – found that on-road NOx emissions from diesel cars were approximately two to five times higher than their type-approval standards, while petrol vehicles met Euro standards under real driving conditions.

As far as greenhouse gas emissions are concerned, the gap between official test results for fuel efficiency and CO_2 emissions and real-world performance on the road continues to grow rapidly.[104] A 2014 study by non-governmental organisation the International Council on Clean Transportation (ICCT) indicates that real CO_2 emissions (and fuel consumption) are on average 38% higher than official emissions measured in laboratory tests during type-approval procedures. It also suggests that the gap between on-road and type-approval has been growing in recent years, from about 8% in 2001.

ICCT analysed results for 600,000 cars across the EU from 11 different datasets to compare real world fuel economy with official test results. They note that the trend is consistent and that for private motorists the gap has grown from 8% in 2001 to 38% in 2014. For company car drivers the gap is now even larger at 45%. The average gap is now 40% and has increased by 9 percentage points in the past two years alone – by far the fastest rate of increase to date. Official test results therefore have limited credibility.

The Spiritmonitor data analysed by the ICCT showed that in 2001, 14% of drivers could match official test results for fuel economy but by 2014, practically nobody could drive their car this economically. At the other end of the spectrum, the least economical drivers now report using virtually twice as much fuel as the official figures suggest they should[105].

[101] EC, Transport emissions http://ec.europa.eu/environment/air/transport/road.htm

[102] EEA, 2004, "Ten key transport and environment issues for policymakers", Term report 3/2004, http://www.eea.europa.eu/publications/TERM2004

[103] Transport & Environment, Mind the Gap, Sep 2015 https://www.transportenvironment.org/sites/te/files/publications/TE_Mind_the_Gap_2015_FINAL.pdf

[104] ICCT, 2015: From laboratory to road: A 2015 update http://www.theicct.org/laboratory-road-2015-update

[105] Transport & Environment, Mind the Gap, 2015 https://www.transportenvironment.org/sites/te/files/publications/TE_Mind_the_Gap_2015_FINAL.pdf

On average, only one third of the improvement in emissions claimed in tests has been delivered on the road since regulations were introduced in 2008.

5.2. Indirect impacts in the EU

In addition to the direct impact on emissions, there is also an indirect impact through the extent to which the emissions gap, and the way in which it has grown over time, has not been reflected in policy development over recent decades. Although discrepancies between real world emissions and the emissions calculated for type approval purposes have been known about since at least the early 2000s, as indicated by the EEA's comment in a 2004 report cited above, the extent to which air quality policies and strategies have taken this gap into account is limited. Documents from the 1990s, for example the explanatory memorandum to the 1994 Commission proposal[106] leading to the adoption in 1996 of Directive 96/62 on Ambient Air Quality, and the Commission's 1995 report on the state of implementation of ambient air quality directives[107] focus on an approach which creates broad obligations for Member States on the results to be achieved, while allowing them to choose the appropriate mix of policies and measures. They address neither the important role of EU single market legislation on transport emissions in providing a baseline for Member State action, nor the reliability of mechanisms for enforcement of that legislation. In the meantime, policy on vehicle emissions seems to have placed a lot of confidence on the effectiveness of the legislative measures adopted, with the Commission's 1996 communication[108] on the Auto Oil Programme noting that:

> "The implementation of the measures arising out of the Auto/Oil Programme will ensure that emissions from road transport are reduced to a level compatible with the attainment of rigorous air quality standards."

A progressive integration of policies on sources of emissions, and on the setting of environmental standards, can be observed from 2000 onwards. The Commission's communication of 2000 on the Auto Oil II programme[109] shows an emerging awareness of issues concerning real world use through its focus on on-board diagnostics, although this seems to be largely framed by concerns about the durability of emissions reduction technologies, rather than discrepancies between test results and immediate real-world emissions. The Clean Air for Europe communication[110] addresses the issue of effective links between sectoral legislation and the CAFÉ programme ("effective structural links between CAFE and the sectoral and source-specific measures will therefore be developed in order to ensure that the necessary measures (whether technical or non-technical) are taken and that scenarios used within CAFÉ and other policy areas are consistent"), but does not address the effectiveness of sectoral legislation, including on vehicle emissions, or record any concerns about the growing gap between real-world and legislated emissions reductions.

The thematic strategy that emerged as a result of the CAFÉ programme in 2005[111] demonstrates awareness of the gap between real-world and test cycle emissions, although limited urgency in tackling it, in the statement that "In the longer term, the Commission will also investigate the feasibility of improving the type approval process so that test-cycle

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106 COM (94) 109 final, "Proposal for a Council Directive on Ambient Air Quality Assessment and Management"
107 COM (95) 372 final, "Report from the Commission on the state of implementation of ambient air quality directives"
108 COM (96) 248 final, "A future strategy for the control of atmospheric emissions from road transport taking into account the results from the Auto/Oil Programme"
109 COM (2000) 626, "A Review of the Auto-Oil II Programme"
110 COM (2001) 245, "The Clean Air for Europe (CAFE) Programme: Towards a Thematic Strategy for Air Quality"
111 COM (2005) 446, "Thematic Strategy on air pollution"

emissions better reflect real world driving". By the time of the publication of a staff working paper[112] in 2011, somewhat greater urgency was visible, with the observation that:

> "The current policy efforts, at EU and national level, have not fully delivered the expected results. Limit and target values of particulate matter, nitrogen dioxide and ground-level ozone are exceeded in many urban areas and global emission of nitrogen oxides (NOx) are not decreasing as much as expected. One [sic] of the reasons is the increase in transport volume, the gap between regulated emission limits in type approval and the "real world" emissions and the slower turnover of vehicles fleets."

Identified short-term policy actions therefore included "addressing the "real world" emissions, including speeding up the adoption of a revised test cycle for the type approval of vehicles".

In summary, the discrepancy between real-world emissions and test cycle results was slow to emerge as an issue in policymaker thinking about air quality strategies, in the EU institutions and among Member States; and there is little evidence that the gap between the emissions reductions initially assumed to be delivered by vehicles legislation, and the emissions reductions being delivered in practice, was integrated into Commission thinking about the overall effectiveness of its air quality strategy.

In the meantime, Member State inventories for emissions of pollutants under the National Emissions Ceilings Directive were largely developed reflecting an assumption that the emissions standards for NOx legislated at EU level were being delivered in practice for the relevant models. While later work has improved the extent to which real world emissions measured by PEMS are incorporated into inventories, there was a period when the effectiveness of policies to reduce NOx emissions was being overestimated, and the emissions themselves underestimated.

Member States policies and measures for delivering air quality standards, which are likely to take into account expected improvements in the emissions standards of the new vehicle fleet, are therefore likely to be less accurate (and less effective) than is required, and to fail to bring forward additional measures (including, for example, traffic restrictions, or investment in abatement technologies from other sources) which would have been identified as necessary had more realistic information on the future pattern of vehicle emissions been available.

5.3. Impacts in the US

As explained above, the overarching purpose of the US Clean Air Act was to "improve human health and the environment" by reducing the levels of harmful pollution found in the air we breathe. This was to be done by focussing on three key areas[113]:

- "reducing outdoor, or ambient, concentrations of air pollutants that cause smog, haze, acid rain and other problems";
- "reducing emission of toxic air pollutants that are known to, or are suspected of, causing cancer or other serious health effects"; and
- "phasing out production and use of chemicals that destroy stratospheric ozone."

According to the EPA, over half of air pollution is emitted by mobile sources such as cars and other engines; one could then conclude that by reducing the level of emissions from mobile sources, there is a greater chance that overall pollution levels would also be reduced. It is

[112] SEC (2011) 342 final, "Commission staff working paper on the implementation of EU Air Quality policy"

[113] The USEPAUS EPAUSEPA, 'The Plain English Guide to the Clean Air Act' https://www.epa.gov/sites/production/files/2015-08/documents/peg.pdf

thought that by implementing the standards set out by the EPA, the following emission reductions could be made by 2030[114]:

- NOx: 2,800,000 tons ≈ 2.47% of NOx emissions from highway vehicles between 2000[115]-2015[116] (113.2 million tons)
- $PM_{2.5}$: 36,000 tons ≈ 0.95% of $PM_{2.5}$ emissions from highway vehicles between 2000-2015 (3.79 million tons)
- VOC: 401,000 tons ≈ 0.76% of VOC emissions from highway vehicels between 2000-2015 (52.98 million tons)

Through Motor Vehicle Emission Simulators, EPA has projected that the emissions of toxic pollutants in 2030 will be 20%[117] of the levels seen in 1990, when their emission regulations were first introduced. It is also projected that through the introduced and proposed standards placed upon vehicles, more than 3,100 million metric tons of CO_2 emissions be avoided[118].

According to studies conducted by the EPA, they have witnessed a sizeable improvement in the cleanliness of vehicles. Since 1970, the level of pollutants, such as hydrocarbons, carbon monoxide, nitrogen oxide and particulate matter, produced from vehicles has been reduced by around 99%. Sulphur levels found in petrol and diesel fuel has also been reduced by 90% and 99% respectively compared to before the introduction of standards relating to such emissions[119]. It is also evident that levels of Volatile Organic Compound (VOC) emitted per mile have also been greatly reduced (see Figure 10).

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[114] The USEPAUS EPAUSEPA Benefits and Costs of Five Important Clean Air Rules in 2030 https://www.epa.gov/sites/production/files/2015-05/documents/2030annualbenefits.pdf

[115] The US EPA Air Emissions Inventories: Average Ennual Emissions 1970-2014 https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data

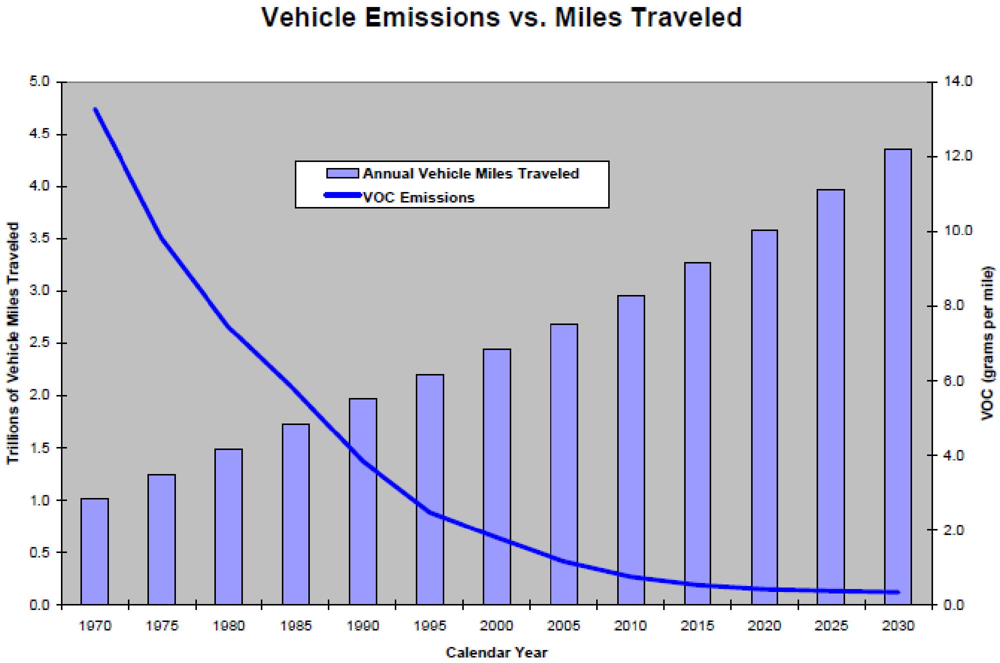
[116] The US EPA (2016) Our Nation's Air: Status and Trends Through 2015 https://gispub.epa.gov/air/trendsreport/2016/

[117] The USEPAUS EPAUSEPA, Progress Cleaning the Air and Improving People's Health https://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health#toxic

[118] The USEPAUS EPAUSEPA, Regulatory Initiatives https://www3.epa.gov/climatechange/EPAactivities/regulatory-initiatives.html#transportation

[119] The USEPA Clean Air Act Overview, https://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health#cars

Figure 10: Vehicle miles travelled compared to VOC emissions per mile.



Source: The USEPA[120]

[120] The USEPA Clean Air Act Overview, https://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health#cars

6. COMPARATIVE ANALYSIS OF EU AND US LEGISLATION ON DEFEAT DEVICES

The use of defeat devices is forbidden in both US and EU legislation, and the wording of the relevant provisions is virtually identical in both cases. However, the recent experience in respect of Volkswagen's use of defeat devices, as uncovered in the US, is revealing. While action has been taken against VW by the US EPA, and VW has accepted that it broke relevant US legislation, no action has yet been taken against VW in the EU, where it's been estimated that the use of defeat devices affected more than 8.5 million vehicles, and the company continues to maintain that the methods it used were legal under the EU framework.

6.1. Definition of "defeat device"

Defeat devices are in principle forbidden in the EU. Article 5 (2) of Euro 6 Regulation 715/2007/EC[121] prohibits the use of defeat devices apart from a few exemptions, including to protect the engine against damage and ensure safe operation.

> Article 3(10) defines defeat device as "*any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use*".

While EU legislation incorporates specific provisions on defeat devices, there is also a more general duty on manufacturers (Article 5 (1)), who are required to "*equip vehicles so that the components likely to affect emissions are designed, constructed and assembled so as to enable the vehicle, in normal use, to comply with this Regulation and its implementing measures*." There is some ambiguity in this wording, however; while a simple reading would assume that it means that vehicles need to comply with the emissions limit values, in practice the text seems to refer in a circular manner to the full range of provisions in the regulation, including exempted defeat devices, and other factors.

The US EPA defines defeat devices based on U.S. regulation 40 Code of Federal Regulation (CFR) §86.1803-01 as follows:

> *"Defeat device means an auxiliary emission control device (AECD)[122] that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use, unless:*
>
> *(1) Such conditions are substantially included in the Federal emission test procedure;*
>
> *(2) The need for the AECD is justified in terms of protecting the vehicle against damage or accident;*
>
> *(3) The AECD does not go beyond the requirements of engine starting; or*
>
> *(4) The AECD applies only for emergency vehicles and the need is justified in terms of preventing the vehicle from losing speed, torque, or power due to abnormal conditions of the emission control system, or in terms of preventing such abnormal conditions from occurring, during operation related to emergency response. Examples*

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[121] Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and 6) and on access to vehicle repair and maintenance information. Accessible at : http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:171:0001:0016:EN:PDF

[122] US Regulation 40 CFR §86.1803-01 defines an AECD as: any element of design which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system.

> *of such abnormal conditions may include excessive exhaust backpressure from an overloaded particulate trap, and running out of diesel exhaust fluid for engines that rely on urea-based selective catalytic reduction."*

US legislation[123] clearly states that "no new light-duty vehicle, light-duty truck, or complete heavy-duty vehicle shall be equipped with a defeat device."

6.1.1. Exceptions to the defeat device ban

While the use of defeat devices that reduce the effectiveness of emission control systems is in principle prohibited, both the EU and US legislation also set out a number of circumstances in which defeat devices may, by derogation, be used. For example, in the EU the prohibition shall not apply where:

> (a) "the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;
>
> (b) the device does not function beyond the requirements of engine starting;
>
> (c) the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions."

Similarly, US legislation does not ban the use of auxiliary devices that hinder the emissions control system on a vehicle under the conditions set out above, which are very similar to those specified in the EU legislation.

There is thus considerable commonality between the US and EU approaches to the definition of "defeat devices", through the reference to any device (etc) which "reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use", and the creation of a number of permitted derogations. The key differences, as explained below, come from the system under which manufacturers are allowed to make use of those exemptions.

6.2. Implementation of the defeat device ban

Although the use of defeat devices is officially banned in both the EU and US, **EU legislation does not provide more detailed prohibition provisions than the generic ban** (plus exemptions) contained in Article 5.2 of the Euro 6 Regulation. Although Commission Regulation 692/2008[124] is supposed to implement this, it does not explicitly define any procedures by which manufacturers are required to disclose defeat devices in advance, or to apply for explicit recognition that a defeat device meets the criteria for one of the exceptions to the prohibition of defeat devices; nor, in consequence, does it assign authority to review such an application; or describe any criteria by which an application should be evaluated by the type approval authority, and or any of the terms under which an exemption may be granted or denied.

Contrary to the EU approach, **US legislation does include a number of provisions** designed to ensure that manufacturers or others do not use defeat devices in order to

[123] US Regulation 40 CFR §86.1809-01 – Prohibition of defeat devices. Available: https://www.law.cornell.edu/cfr/text/40/86.1809-01

[124] Commission Regulation (EC) No 692/2008 of 18 July 2008 implementing and amending Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information. Available : http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32008R0692

undermine the effectiveness of the legislation in controlling emissions[125]. Section 203 of the Clean Air Act (CAA), which specifies the prohibited acts with respect to the emissions standards[126], prohibits manufactures from selling/distributing any new motor vehicle[127]:

1) that is not covered by a Certificate of Conformity (COC) issued by the EPA (certification requirements);
2) if the manufacturer has failed to disclose the existence of the defeat device [according to EPA´s definition] in the COC applications for test groups for new vehicles (reporting requirements);
3) if the manufacturer has installed a device that removes or renders inoperative devices or elements of the emission control system installed to comply with regulation (anti tampering requirements); and/or
4) if the manufacturer has installed a component to bypass, defeat, or render inoperative any device or element of design installed in compliance with CAA regulations.

Therefore, the US approach goes significantly further than the EU legislation in requiring both the **presence of and rationale for defeat devices to be disclosed to the regulator**[128]. Moreover, in order to ensure that manufacturers comply with points 2 to 4 above, EPA has provided a set of **specific disclosure requirements within the certification process**. For example, when manufacturers apply for certification in the US, they are required to disclose the list of all AECDs installed, and for each AECD installed to provide "a justification (...), the parameters they sense and control, a detailed justification of each AECD which results in a reduction in effectiveness of the emission control system, and rationale for why the AECD is not a defeat device[129]". Moreover, if the EPA would like to further investigate the existence of potential defeat devices, "upon request by the Administrator, the manufacturer must provide an explanation containing detailed information regarding test programs, engineering evaluations, design specifications, calibrations, on-board computer algorithms, and design strategies incorporated for operation both during and outside of the Federal emission test procedure"[130]. Finally, the EPA has the authority to disapprove manufacturer's justification for reduced performance through AECDs where there are technological alternatives that do not present the same level of constraints[131]. In addition to the existence of enforcement mechanisms, the EPA has provided manufacturers and its own evaluators with a **set of Advisory Circulars (ie internal guidelines) in order to clarify how the defeat device ban is implemented**[132]. These Advisory Circulars provide further specifications on how the existence of any AECDs must be explained, specifying for example a justification for its use, what parameters is the AECD sensing and/or calculating, an

[125] ICCT, 2016. Defeat devices under the U.S. and EU passenger vehicle emissions testing regulations. Prepared by Rachel Muncrief, John German, and Joe Schultz – ICCT Briefing Note – March 2016. Available online at http://www.theicct.org/sites/default/files/publications/ICCT_defeat-devices-reg-briefing_20160322.pdf

[126] Congressional Research Services (2016) – Volkswagen, Defeat Devices, and the Clean Air Act: Frequently Asked Questions. February 10 2016. Available online at https://www.fas.org/sgp/crs/misc/R44372.pdf

[127] U.S. Code of Federal Regulations, Title 42 Chapter 85, Subchapter II, Part A, 7522 – Prohibited Acts. The text is online at https://www.law.cornell.edu/uscode/text/42/7522

[128] Megan Geuss, "Volkswagen's emissions cheating scandal has a long, complicated history," ArsTechnica, 8 October 2015, http://arstechnica.com/cars/2015/10/volkswagens-emissions-cheating-scandal-has-a-longcomplicated-history/

[129] US Regulation 40 CFR §86.1809-01 – Prohibition of defeat devices. Available: https://www.law.cornell.edu/cfr/text/40/86.1809-01

[130] US Regulation 40 CFR §86.1809-01 – Prohibition of defeat devices. Available: https://www.law.cornell.edu/cfr/text/40/86.1809-01.

[131] Transport and Environment, 2016 – Comparison of EU and US Defeat Device Legislation – May 2016.

[132] MSPC Advisory Circular – Prohibition of use of Emission Control Defeat Devices. December 11, 1972. Advisory Circular No 24. Accessible here: https://iaspub.epa.gov/otaqpub/display_file.jsp?docid=14341&flag=1

estimation of the emissions impact from the use of the AECD, etc. Documented examples of AECDs making use of the exemptions include the EPA's emergency vehicle exemption[133] relaxing regulatory requirements for engines within certain emergency vehicles (eg ambulances and fire apparatus). Documented cases of approved AECDs within the private sector are not publicly available due to commercial confidentiality issues[134].

The type of supporting documentation and the level of detail that is required under the US system is **completely absent from the EU system and there is no clear legal basis for its development**. Arguably this lack of guidance has contributed to inconsistency and inaction in the way the regulations are enforced, and to the lack of examples of AECDs making use of the exemptions and how they are monitored. As a result, off-cycle emissions control strategies that have been rejected or declared illegal in the United States have gone undeclared and unchallenged in the EU (at least until quite recently). Regulation 692/2008 on the Euro 5 and 6 emissions standards does require information to be provided for diesel cars regarding the operation of their exhaust gas recirculation system and any aftertreatment devices. Type Approval Authorities (TAAs) are also directed that they should not grant type approval if they are not satisfied that certain emissions control conditions are met. However, the criteria specified are quite narrow and the level of detail required in the information to be provided to the TAA is not very specific. Although the details of the transactions that result are not in the public domain, it must be assumed that the information provided was not sufficient to raise any objections in most recent cases across the EU. More broadly, it has become clear in the wake of the Dieselgate affair, and especially through the national testing programmes implemented in Germany, France and the UK, that a much wider range of techniques are being used in Europe than in the US that are having the effect of greatly increasing real-world NOx emissions relative to those of the official testing procedures.

6.3. Enforcement of defeat device legislation

In the EU the enforcement of the defeat device ban is **left to the national type approval authorities to administer and implement**. Thus while it is the responsibility of national type approval agencies to enforce the defeat device ban and verify the legitimacy of the exemptions used, they have limited tools at their disposal to enable them to do so. In the event that a manufacturer chooses to rely on one of the exemptions to the ban on defeat devices, but does not communicate that choice to the type approval authority, it is difficult to see how the TAA would be able to enforce the ban without the commitment of significant additional resources to forensic investigation. Regulation (EC) No 715/2007, Article 13 specifies that Member States need to "lay down the provisions on penalties applicable for infringement by manufacturers of the provisions of this Regulation and [to] take all measures necessary to ensure that they are implemented"[135]. After a review of the different provisions laid down by Member States, a recent working document showed that only 18 out of the 28 Member States had sent information on the provisions/penalties put in place, these ranging "from fines to withdrawal of type approval, recall and repair obligations, and prison"[136].

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133 EPA Grants Relief for Fire Trucks and Ambulances – US Environmental Protection Agency. Available : https://www3.epa.gov/otaq/highway-diesel/regs/420f12025.pdf

134 See for example sections 11 and 16 of the Application for Certification for Ford Motor Company 2014 Model Year. Available: https://iaspub.epa.gov/otaqpub/display_file.jsp?docid=32040&flag=1

135 Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007on type approval of motor vehicles with respect to emissions from light passenger and commercialvehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information. Available : http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:171:0001:0016:EN:PDF

136 ICCT briefing (March 2016): Defeat devices under the U.S. and EU passenger vehicle emissions testing regulations ;prepared by Rachel muncried, John German, and Koe Schultz. Available : http://www.theicct.org/sites/default/files/publications/ICCT_defeat-devices-reg-briefing_20160322.pdf

In the US, enforcement of the defeat device ban is the responsibility of the **EPA to administer and implement**. The US government has put in place a series of key emission tests[137] where the manufacturer is tested in order to ensure that the new motor vehicle does not "incorporate strategies that unnecessarily reduce emission control effectiveness when the vehicle is operated under conditions that may reasonably be expected to be encountered in normal operation and use (eg within a temperature range of 20 to 86 °F (-6.7 to 30 °C)"[138]. As a result of the prior screening, enforcement activity in the US is not normally required except in cases where either the manufacturer has failed to declare or properly characterise an AECD, or where vehicles in use are found to be operating or to be using equipment that differs significantly from what was declared in the original application.

Finally, if an infringement of the defeat device ban is found, the EPA is also the authorised body to seek **civil penalties or injunctive relief,** including corrective, remedial and disciplinary actions for violation of the Clean Air Act. According to a recent note by Transport and Environment[139], "enforcement actions include cases against a variety of parties, including manufacturers, importers, distributors, and consultants. Violators are subject to civil penalties up to $37,500 per noncompliant vehicle or engine, $3,750 per tampering event or sale of defeat device, and $37,500 per day for reporting and recordkeeping violations (42 U.S.C. § 7524; 40 C.F.R. § 19.4)". In contrast to the EU, where responsibilities are in practice unclear (with potentially three actors - the Member State issuing the type approval; the Member State discovering any discrepancy; and the European Commission - involved in judgements over whether to take action and what action to take), there is thus clarity in the US on the responsibility for identifying, pursuing and remedying breaches of the legislation by manufacturers. It is also helpful that the responsibility lies with a body which (i) has significant experience of enforcement through the courts and (ii) has a primary function of protecting the environment and human health, in contrast to the majority of relevant authorities in the EU, whose administrative role is more closely aligned with transport and single market policy.

6.4. Possible uses of defeat devices in the EU

Experience in respect of VW's use of defeat devices, as uncovered in the US, is revealing. While action has been taken against VW by the US EPA (see 6.5.2 below), and VW has accepted that it also broke relevant US legislation, no action has yet been taken against VW in the EU, and the company continues to maintain that the methods it used were legal under the EU framework.

In spite of the underlying similarities in the wording of the legislation in the EU and US, the lack of underpinning detail, prior notification of defeat devices and the lack of proactive enforcement action by the European TAAs have together led to a very different understanding of what is actually allowed. It also means that, while the US system provides details on identified illegal uses of defeat devices, similar information is not available in the EU. There are, however, a number of pieces of independent research and investigation which have pointed to the existence of techniques and devices whose compliance with the legislation appears open to question.

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137 Federal Test Procedure or Supplemental Federal Test Procedure (FTP or SFTP) or the Highway Fuel Economy Test Procedure (described in subpart B of 40 CFR part 600), or the Air Conditioning Idle Test (described in §86.165-12. Source: Transport and Environment, 2016 – Comparison of EU and US Defeat Device Legislation – May 2016

138 40 CFR §86.1809-12, point d

139 Transport & Environment, Mind the Gap, 2015 https://www.transportenvironment.org/sites/te/files/publications/TE_Mind_the_Gap_2015_FINAL.pdf

In the sections that follow, some of the main techniques that have been discovered in use in Europe, and that look like they might be considered to constitute defeat devices, are briefly outlined.

Thermal window

It has become clear that in a number of examples, emissions control technology is switched off or operated at reduced intensity when the ambient temperature falls above or below certain values. Several manufacturers have offered detailed technical justifications of why this is necessary, but these often appear unconvincing.

Indeed, ICCT points out that ambient temperature is a very poor parameter to choose for determining the operation of an engine or emissions control system, as both generally operate at temperatures much higher than ambient, and these are only affected by the ambient temperature in the first seconds and minutes after a cold start. This in itself should therefore arouse suspicion.

They also stress that the restricted thermal windows chosen by some manufacturers are clearly inappropriate:

> "... the temperature ranges cited by Renault and BMW [in which emissions control is fully operative] are narrower than any reasonable definition of normal conditions. Ambient temperatures below 17 °C (Renault's lower range) or 10 °C (BMW's) are common in Europe. The average temperature is below 17 °C in Paris 83% of the time, and below 10 °C 42% of the time; in London it is below 17 °C 75% of the time and below 10 °C 33% of the time."

In short, these criteria clearly would not stand up to close scrutiny against the exceptions allowed for a legitimate engine control strategy: they are clearly effective in detecting the conditions of a laboratory test, however.

Other methods of test recognition

The thermal window is the best known and probably the most easily understood of the methods that might be used to detect test conditions and control the operation of the vehicle in order to make it perform differently in test cycle and on-road conditions.

However, as cars become more sophisticated they incorporate more and more sensors of their internal operating conditions and external environment, and as a result there are a growing number of ways to detect test conditions and behave accordingly. These might include, for example, detection of any movement in the steering system; registering whether the rear wheels were going round at the same speed as the front ones; detection of a wall or other object that did not come closer as the drive wheels rotate, etc.

Hot restarts

It is also been found in many of the diesel cars tested recently that emissions are much higher when they are restarted from hot than with a cold engine. Again, while a number of technical explanations have been offered as to why this might occur, several questions arise, as the EU testing procedure begins from a cold start, suggesting that two different emissions control strategies may be in use in order to reduce the results from emissions testing.

In spite of all of the above, **no enforcement action within the EU** has been taken against the major manufacturers by a TAA. Informal action may have been taken in some cases to encourage manufacturers to take remedial action where a very large gap between test results and real-world emissions has been revealed. These actions have typically involved updates to engine control software that have reduced the level of off-cycle NOx emissions.

6.5. Defeat devices used in the US

Despite the media coverage received by the recent Volkswagen defeat device scandal[140], enforcement cases about the illegal use of defeat devices in the US have several precedents in recent decades[141]. Since soon after the first version of the Clean Air Act was passed in 1963, the EPA has sought civil penalties against manufacturers for the illegal installation of defeat devices (for a selection of historic cases, see Table 10). All enforcement notices in the US are published on the EPA's website on an annual basis, along with relevant supporting documentation. Typically these amount to about 20 to 30 cases per year, and usually they represent actions relating to relatively small numbers of vehicles and to relatively small-scale manufacturers rather than the global carmaking giants. Recent exceptions included Hyundai and Kia in 2015, and more recently Volkswagen.

Table 10: Defeat Device Cases under Title II of the Clean Air Act

Company	Year	Civil Penalties	Additional Relief	Affected Vehicles/Equipment
Volkswagen[142]	2015	In process	Partial Settlement for 2.0 litre engines: Mandatory recall or emissions modification of at least 85% affected vehicles; plus \$2.7 billion to mitigation trust; plus \$2 billion investment in the promotion of Zero Emission Vehicles[143]	584,000 MY2009-MY2015 diesel cars
Casper's Electronics[144]	2013	\$80,000	Mandatory recall/ repurchase program; destruction of recalled devices	44,000 aftermarket "oxygen sensor simulators"
Edge Products LLC[145]	2013	\$500,000	Mandatory repurchase program; \$157,600	9,000 aftermarket electronic devices sold from 2009 to 2011 that allowed

[140] BBC: Volkswagen: The scandal explained By Russell Hotten. Business reporter, BBC News. 10 December 2015. Accessible: http://www.bbc.co.uk/news/business-34324772

[141] Megan Geuss, "Volkswagen's emissions cheating scandal has a long, complicated history," ArsTechnica, 8 October 2015, http://arstechnica.com/cars/2015/10/volkswagens-emissions-cheating-scandal-has-a-longcomplicated-history/

[142] US Environmental Protection Agency: Volkswagen Light Duty Diesel Vehicle Violations for Model Years 2009-2016. Accesible: https://www.epa.gov/vw

[143] EPA - Volkswagen Clean Air Act Partial Settlement. Accessible : https://www.epa.gov/enforcement/volkswagen-clean-air-act-partial-settlement#civil

[144] US Environmental Protection Agency: Casper's Electronics Inc. Clean Air Act. Accessible : https://www.epa.gov/enforcement/caspers-electronics-inc-clean-air-act

[145] US Environmental Protection Agency : Edge Products LLC settlement, Accessible : http://www2.epa.gov/enforcement/edge-products-llc-settlement

			in rebates to upgrade older wood-burning stoves	for the removal of emissions equipment
Ford Motor Company[146]	1998	$2.5 million	$1.3 million to modify affected vehicles; plus $4.0 million to purchase nitrogen oxide credits and to support environmental projects	60,000 MY1997 vans
American Honda Motor Co.[147]	1998	$12.6 million	$250 million to extend emissions warranties and provide maintenance; plus $4.5 million in other environmental projects	1.6 million MY1995-MY1997 passenger vehicles
General Motors Corp.[148]	1995	$11 million	$25 million recall and retrofit; plus $9 million in other actions (may include older vehicle buyback or purchasing new school buses)	500,000 MY1991-MY1995 passenger vehicles
Volkswagen[149]	1974	$120,000	None	25,000 MY1973 passenger vehicles

[146] Clean Air Act Prohibits « Defeat Devices » in vehicles, Engines ; US EPA, Office of Enforcement and Complicance Assurance. Enforcement Alert August 1998, EPA 300-N-98-005. Accessible : http://www2.epa.gov/sites/production/files/2014-06/documents/defeat.pdf https://www.epa.gov/enforcement/ford-motor-company-clean-air-act-settlement

[147] American Honda Motor Company Clean Air Act Settlement ; US EPA. Accessible : https://www.epa.gov/enforcement/american-honda-motor-company-clean-air-act-settlement

[148] http://www.justice.gov/archive/opa/pr/Pre_96/November95/596.txt.html

[149] ENR PRess Release: U.S. Announces $45 Million Clean Air Settlement With GM First Judicial Environmental Recall -- 470,000 Cadillacs. Accessible : http://www.autosafety.org/sites/default/files/imce_staff_uploads/VW%20Defeat%20Device%20$120,00%20fine%203-12-74%20Pr.pdf

Chrysler, Ford, General Motors, and Toyota	1973	None	Remove ambient temperature sensors from new vehicles	

Source: (Adapted from Congressional Research Services, 2016; EPA, 2016).

6.5.1. The 1998 Honda and Ford Cases

In June 1998, two large car manufacturers, American Honda Motor Company (Honda) and Ford Motor Company (Ford), were involved in two defeat devices cases that resulted in major settlements with the EPA and the U.S. Department of Justice (DoJ). The agencies jointly brought a case against each of the car manufacturers alleging the illegal sale of car engines equipped with defeat devices that resulted in the alteration of the engines' emission-control systems, and therefore violating the Clean Air Act[150]. Both cases reached an agreement where the car manufacturers agreed to settle with the agencies and paid civil penalties of $12.6 million (Honda) and $2.5 million (Ford), plus additional relief penalties, which at the time represented the "largest Clean Air Act Settlement in history[151]".

In the **Honda case**, the EPA filed a complaint against the car manufacturer for failing to disclose adequately the use of an AECD, as well as additional disablements, during the application for a Certificate of Conformity (COC) for the 1996 and 1997 MY Honda Accords, Civics, Preludes, Odysseys, and Acuras, as well as 1995 Honda Civics, affecting a total of approximate 1.6 million cars sold in the country. The infringement was discovered when engineers of the California Air Resources Board (CARB) tested a vehicle that had passed federal standards and found that the vehicle failed to diagnose engine misfires[152]. According to the EPA, Honda's defeat device disabled the engines' misfire monitoring device that prevented the car's On-Board Diagnostic System from alerting the owner when the engine needed to be serviced. The malfunctioning of the misfire monitoring device resulted in higher exhaust emissions of hydrocarbons and potential damage to the vehicle's catalyst.

Although Honda denied the accusations of failing to comply with the Clean Air Act, the car manufacturer agreed to settle with the EPA-DOJ, and a related additional agreement with the California Air Resources Board. As part of the settlement[153], Honda agreed to:

- Pay a total of $17.1 million, which includes $12.6 million in civil penalties and $4.6 million to "implement environmental projects to reduce pollution"
- Spend an additional $250 million on additional relief measures for all affected models, including extending emission warranties, providing engine and warranty repairs needed after certain mileage, as well as free tune ups and oil changes within certain mileage.

[150] Clean Air Act Prohibits « Defeat Devices » in vehicles, Engines ; US EPA, Office of Enforcement and Complicance Assurance. Enforcement Alert August 1998, EPA 300-N-98-005. Accessible : http://www2.epa.gov/sites/production/files/2014-06/documents/defeat.pdf https://www.epa.gov/sites/production/files/2014-06/documents/defeat.pdf

[151] EPA Press release: "American Honda Agrees To $267 Million Settlement To Resolve Clean Air Act Violations Largest Clean Air Act Settlement in History". 08/06/1998. Accessible : https://yosemite.epa.gov/opa/admpress.nsf/016bcfb1deb9fecd85256aca005d74df/46c8f6584782b19085256628005f62b3?OpenDocument&Highlight=0,honda

[152] New York Times : Honda and Ford are fined millions, by Matthew L. Wald. June 9, 1998. Accessible : http://www.nytimes.com/1998/06/09/us/honda-and-ford-are-fined-millions.html

[153] USA District Court – Consent Decree (1998) : US v. American Honda Motor Company. Accessible : https://www.epa.gov/sites/production/files/2013-10/documents/amerhonda-cd.pdf

- "Notify owners of affected vehicles three times during the life of the vehicles"[154]

In the **Ford Case**, the agencies filed a Complaint after finding that the car manufacturer had installed a defeat device within the 1997 Ford Econoline vans, affecting approximately 60,000 vans sold in the country. The defeat devices aimed to improve the engine's fuel efficiency but resulted in alterations of the car's emission-control systems. According to the EPA, "the system caused smog-causing nitrogen oxide emissions to increase well beyond the limits of the CAA emission standards when the vans are driven at highway speeds"[155].

Although Ford also denied the accusations of failing to comply with the Clean Air Act, the car manufacturer agreed to settle with the EPA-DOJ, and a related additional agreement with the California Air Resources Board. As part of the settlement[156], Ford agreed to:

- Pay a total of $6.84 million, which includes $2.84 million in civil penalties[157], up to $2.5 million for the purchase of 2,500 tons of nitrogen oxide credits, and spend $1.5 million "on projects designed to reduce harmful pollutants in the air"
- Spend up to $1.3 million in order to deactivate the defeat device in all affected vehicles.

6.5.2. Volkswagen Case (2009-2015)

In September 2015, the EPA-DOJ and the California ARB filed two separate complaints against Volkswagen[158] for the illegal sale of vehicles and engines equipped with defeat devices that enable the cars to operate under two emission-control regimes. One regime would recognise when the vehicle was undergoing certification test procedures and would produce emissions compliant with CAA. Outside of testing conditions the device would switch to conditions that optimise other performance characteristics while producing higher emissions, violating EPA emission standards for nitrogen oxides. Due to the operation of this switch, the infringement was only found after a team of researchers from the US NGO International Council on Clean Transportation (ICCT) and a team from University of West Virginia conducted independent testing using portable emissions testing equipment[159]. The infringement has been found in more than 16 diesel vehicle models from 2009 to 2015[160], affecting approximately 584,000 vehicles sold just in the US[161].

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[154] USEPA. 1998. Clean Air Act Prohibits « Defeat Devices » in Vehivles, Engines. Enforcement Alert : https://www.epa.gov/sites/production/files/2014-06/documents/defeat.pdf

[155] USEPA. 1998. Clean Air Act Prohibits « Defeat Devices » in Vehivles, Engines. Enforcement Alert : https://www.epa.gov/sites/production/files/2014-06/documents/defeat.pdf

[156] USA District Court – Consent Decree (1998) : US v. Ford Motor Company. Accessible : https://www.epa.gov/sites/production/files/documents/fordmotor-cd.pdf

[157] $2.5 million from EPA-DOJ settlement and $335,000 from the California ARB settlement

[158] Volkswagen AG, Audi AG, Volkswagen Group of America, Inc., Volkswagen Group of America Chattanooga Operations, LLC, Porsche AG, and Porsche Cars North America, Inc.

[159] Nieuwenhuis, P (2015). How this clean air NGO caught Volkswagen cheating emissions tests. Fortune Insiders, 23.09.2015. Accessible : http://fortune.com/2015/09/23/volkswagen-carbon-emissions-scandal/

[160] Affected 2.0 litre diesel models and model years : Jetta (2009-2015), Jetta Sportwagen (2009-2014); Beetle (2013-2015); Beetle Convertible (2013-2015); Audi A3 (2010-2015) ; Golf (2010-2015) ; Golf Sportwagen (2015) ; Passat (2012-2015). Affected 3.0 litre diesel vehicle models and model years : Volkswagen Touareg (2009-2016) ;Porsche Cayenne (2013-2016) ; Audi A6 Quattro (2014-2016) ; Audi A7 Quattro (2014-2016) ; Audi A8 (2014-2016) ; Audi A8L (2014-2016) ; Audi Q5 (2014-2016) ; Audi Q7 (2009-2016). Source : https://www.epa.gov/vw

[161] VW has also acknowledged that some 11 million vehicles worldwide had similar software, including more than 8 million in Europe. Source : ICCT (2016) : http://www.theicct.org/sites/default/files/publications/ICCT_defeat-devices-reg-briefing_20160322.pdf

On June 2016, EPA announced a major partial settlement[162] with Volkswagen resolving the alleged violations of the CAA on the sale of 2.0 litre diesel engines. As part of the settlement, Volkswagen has agreed to:

- Spend up to $10.033 billion in order to recall or perform an emissions modification on at least 85% of the affected vehicles and pay a compensation to all affected owners for consumer damages
- Pay $2.7 billion for the establishment of a mitigation trust to fully remediate the excess nitrogen oxide emissions from affected vehicles, and invest an additional $2 billion in the promotion of zero emission vehicles (ZEVs) and ZEV technology.

This $14.7 billion settlement is only partial since it only covers allegations of CAA violations for Volkswagen's 2.0 liter diesel vehicles. According to the Federal Trade Commission[163], "the settlements do not resolve pending claims for civil penalties or any claims concerning 3.0 litre diesel vehicles. Nor do they address any potential criminal liability".

6.6. Concluding comments on defeat devices

The use of defeat devices is forbidden in both US and EU legislation. As described above, the basic language used in the US and EU regulations prohibiting defeat devices, and defining the conditions for exceptions, is virtually identical. However, the regulations have been implemented very differently as a result of the very different institutional settings. Enforcement of the defeat device ban in the US is the responsibility of the EPA to administer and implement. Over the years extensive supplementary guidance and specific requirements have been developed by the EPA to facilitate the effective implementation of the regulation. Key requirements for manufacturers to disclose the existence and justification for each AECD installed in a vehicle's engine place a strong burden of proof on the manufacturer to prove the legitimacy of all its emissions control equipment and operation, and equally an obligation on the regulator to verify that each AECD is indeed allowable. In the EU, by contrast, the enforcement of the defeat device ban is left to each national type approval authority to administer and implement, and there is no specific process defined in legislation under which manufacturers are required either to reveal their reliance on, or secure prior approval for, the use of the derogations from the ban on defeat devices. This is highly unusual in EU environmental legislation, where the use of derogations either by competent authorities or by regulated entities is almost invariably subject to some mechanism for explicit or implicit approval. This approach has contributed to lower stringency and clarity in the EU system as compared with the US.

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[162] To read more about the Partial Settlement : https://www.epa.gov/enforcement/volkswagen-clean-air-act-partial-settlement

[163] Federal Trade Commission (2016) : Volkswagen to Spend up to $14.7 Billion to Settle Allegations of Cheating Emissions Tests and Deceiving Customers on 2.0 Litre Diesel Vehicles. Accessible : https://www.ftc.gov/news-events/press-releases/2016/06/volkswagen-spend-147-billion-settle-allegations-cheating

7. AN OUTLINE OF POTENTIAL IMPACTS OF THE EU LEGISLATION AND ITS IMPLEMENTATION ON THE BEHAVIOUR OF STAKEHOLDERS

This study has not involved a detailed analysis of the behaviour of vehicle manufacturers and other stakeholders in response to the EU and US legislation on vehicle emissions and its enforcement. A number of tentative deductions can be offered, however; and indeed, many have already been identified by the European Commission in its proposals for amendment of the type approval system. It should be noted that the likely behavioural impacts we identify below may be exhibited either with, or in the absence of, explicit strategies and decision-making processes by the actors concerned.

Maximising the use of allowed flexibilities

Where testing standards incorporate allowed flexibilities and tolerated margins for exceedance – as for example, in the case of tyre selection, or conformity factors to reflect inherent variability of test results, it is likely that manufacturers will both lobby for the maximum flexibility in the development of the legislation, and that their engineers will then incorporate that tolerance in their strategies for meeting type approval requirements[164]. A balance needs to be struck between predictability for economic operators, and achievement of the public benefits that the legislation is designed to deliver. However, it is clearly important to keep such flexibilities, and their use, under constant review, and curtail them wherever technically feasible; and where flexibilities are allowed which have a predictable impact in allowing the test performance to underestimate real world emissions, that impact should be explicitly acknowledged in the legislation, and in its support impact assessment.

Manufacturer freedom to choose type approval authorities and testing facilities

The freedom for manufacturers to choose the national type approval authority they use, and the testing facilities they use (including the use of their own in-house facilities, where accredited) creates a strong potential that, over time, they will tend to make use of the type approval authority likely to be most favourable to the passing of their vehicle. While there are also a range of legitimate, practical reasons for this flexibility, its potential impact on the rigour of testing and type approval decisions is clear. Moreover, manufacturers who, as things stand, took a rigorously honest approach to ensuring the accuracy with which their test results reflected real-world emissions would place themselves at a market disadvantage by comparison with their competitors.

[164] The gap between real-world and laboratory tests emissions can be attributed to three factors: 1) an outdated test procedure NEDC; 2) flexibilities in the current procedure, allowing manufacturers to optimise performance; and 3) in-use factors depending on the driver or other aspects. The ICCT has examined the contribution of the widening gap between test and real-world results. According to their analysis, the widening of the gap is not caused by the unrepresentative test cycle (as that has remained unchanged); nor by the way cars are driven (which does not appear to be significantly different). Instead it results from carmakers: 1. Increasingly exploiting loopholes and flexibilities in the testing procedure including "cyclebeating" techniques to unfairly reduce emissions during a test ; 2. Deploying technology on cars that has benefits principally in the test but not on the road 3. Fitting increasing amounts of equipment to cars that is switched off during the test – such as air conditioning.
Source : ICCT: NOx emissions of diesel cars in the lab and on the road
http://www.theicct.org/sites/default/files/RW%20emissions%20diesel%20vehicles_TNO_EP-EMIS_240516.pdf

Type approval authority approach to the rigour of testing and enforcement

Similarly, type approval authorities are likely to want to retain the trust and confidence of manufacturers, and in consequence may find it more difficult to apply test regimes with rigour, or to make a significant effort to identify and pursue discrepancies between test cycle performance and likely or observed real-word emissions. While not all type approval authorities are likely to describe manufacturers as their “customers”, as the UK’s VCA does on its website, or refer explicitly to competition among type approval authorities[165], the reality is that they will in general be dependent on manufacturers for activity and fees, which creates a potential conflict of interest, particularly at a time of downward pressure on the public expenditure available to enforcement authorities.

The absence in the EU legislation of an equivalent to the US legislation’s requirement on manufacturers to communicate a full description of their emissions control strategy, the auxiliary emissions control devices used, and their expected emissions impact, means that there is limited information on which the type approval authority could identify any anomalies; and they have limited incentive to go looking for them.

Dispersal of regulatory responsibility

The principal structural difference between the US regime and the EU regime is that in the US a single regulatory authority applies the legislation on type approval in respect of vehicle emissions. There is evidence, including in the discussion of enforcement responses to the VW scandal, that, while in principle the Member State responsible for issuing the initial type approval has the responsibility for enforcing the requirements of the legislation on the manufacturer when discrepancies come to light, the dispersed structure in the EU leads to a lack of clarity on who has the responsibility (at which level, as between the Commission and Member State competent authorities; and geographically, as between competent authorities in terms of responsibility for identifying discrepancies) to take enforcement action when concerns do come to light.

Enforcement of the legislation and pursuit of breaches of the legislation

Finally, even without taking account of the dispersed nature of regulatory authorities, the nature of type approval authorities, which are technical enforcement bodies with a primary function of ensuring fair treatment of manufacturers under the legislation, appears to mean that they have less of an incentive to take enforcement action. Type approval authorities are not, for example, the first body criticised in response to exceedances of air quality standards under EU legislation. The fact that in the US the regulatory authority is the EPA, which has a principal public mission to “protect human health and the environment”, also means that it has a clearer interest in the effective identification and pursuit of breaches of the legislation. The EPA, like other environmental enforcement bodies, has substantial experience of pursuing legal action against regulated entities; while we have not carried out an investigation on this point, it seems unlikely that similar in-house legal expertise exists in type approval authorities across the EU.

[165] “Many of our services compete with European public sector and international private sector providers”; VCA, Annual Report and Accounts 2015–16, 16 July 2015, quoted in the House of Commons Transport Select Committee report “Volkswagen emissions scandal and vehicle type approval”, HC 69, 15 July 2016.

8. CONCLUSIONS AND POLICY OUTLOOK

The first conclusion that emerges from the analysis is that (regardless of the stringency of the standards themselves) the **US system for implementation and enforcement of emissions standards for new vehicles, and for the ban on defeat devices, is significantly more stringent, coherent and comprehensive**. Key contributing factors to this, in our view, are the existence of the EPA as a single national regulator of vehicle compliance with regulatory standards; and the fact that as a regulator the EPA's primary purpose is the protection of the environment and human health. Secondly, there appears to be significant uncertainty about both the reach and the enforcement of the EU legislative ban on defeat devices, particularly in the light of discussions about whether the VW systems brought to light in the US are illegal under the EU legislation, and over which authorities should take action. Given the apparent lack of clarity surrounding the application of the definition in the EU, reinforced by the lack of a requirement on manufactuerers to provide information on (and seek implicit or explicit approval for their reliance on exemptions), it could be predicted that manufacturers would test the limits of what is and is not allowed. It is surprising, and a prima facie indication of a mismatch of regulatory incentives, that no cases against manufacturers have been brought since the ban was introduced. **It seems likely that type approval authorities have either been insufficiently interested in pursuing discrepancies, or hesitant about entering into legal cases with often well-funded and influential businesses. This is likely to be in part due to lack of sufficient resources and expertise in individual Type Approval Authorities, and in part due to the lack of clarity which could have been generated either through explicit guidance at EU level, or legal precedents from earlier enforcement cases.**

The single market origins of EU legislation on vehicle emissions standards has left us with a legacy of a type approval system which is **more adapted to the task of ensuring that Member States do not use vehicle emissions legislation to penalise manufacturers from other Member States** than it is to what is, now, its primary purpose, the task of **ensuring that emissions reductions are achieved in line with legislative standards adopted at EU level**. While the looser federal structure of the EU, the absence of an EU-level environmental regulator with enforcement powers equivalent to the EPA, and the likely level of cost involved, makes it more difficult to move towards a system based on a single regulator[166], at least in the short term, we recommend a number of options for consideration in the future development of the type approval system:

- **Oversight by organisations having a primary mission of environmental protection**, to the extent that this can be achieved alongside effective implementation of type approval requirements relating to other priorities, such as vehicle safety;
- **A system of allocation of type approval decisions to type approval authorities**, and of test functions for individual manufacturers to approved test facilities, **based on an assessment of the most effective and appropriate allocation**, rather than on the preference of the manufacturer; and, if a system of manufacturer choice is maintained, further steps should be taken to separate the financial interests of test facilities in securing business from manufacturers from their professional/legal interest in rigorous application of the test protocols;

[166] The establishment of authorities such as the European Chemicals Agency at European level does, however, suggest that such an approach is possible, particularly in major sectors with a significant economic and environmental presence.

- Introduction of a requirement on manufacturers, similar to that applying in the US, to **declare in advance to the type approval authority the full list of the auxiliary emissions control devices used**[167], and the rationale for each, together with a statement in relation to expected discontinuities in emissions control performance (for example, at different speeds and temperatures), and an explanation for any such discontinuities;
- A **significant enhancement in the transparency** of the type approval system ensuring that test results and other information (including coast-down test results) is made publicly available, enabling civil society organisations to assist public authorities in the identification and investigation of discrepancies;
- **Clear rules obliging competent authorities at national level to investigate** any cases that come to their attention of discrepancies between test data and real-world performance, together with clarification that any type approval authority may initiate action against a manufacturer it suspects of transgressing the ban on defeat devices (while the primary responsibility for so doing rests with the authority which granted the type approval in question).
- At an EU level, we recommend that the **Commission should be given powers to monitor the performance of Type Approval Authorities**, including through the commissioning of independent checks on the emissions of vehicles as marketed, and – where a TAA is clearly failing to identify strategies aimed at manipulating test data – to suspend a TAA's authority to issue type approvals. The resources necessary for such an enhanced role could be generated through the new system of rules on the testing and type approval fees paid by manufacturers.
- **Current flexibilities for manufacturers to choose which vehicles** are submitted for testing, and to prepare them to optimise test performance, **should be reviewed**, and, wherever possible, curtailed.
- Finally, mechanisms should also be considered which (i) require type approval bodies or other environmental regulators to operate a **random sampling and testing of vehicles marketed**, and pursue any discrepancies with the test results on which type approval was based, including through the temporary withdrawal of type approval pending the provision of satisfactory explanations, and (ii) require the provision and reporting of **direct real-time emissions data** from on-board measurement systems on a sample of vehicles, throughout their lifetime use, in order to provide further evidence of any discrepancies.

The Commission's proposals for an improvement in the type approval system address some of the shortcomings of the present system. However, they do not appear to introduce either a sufficiently powerful EU-level oversight of type approval decisions; or sufficient incentive to persuade type approval authorities to take action in cases of suspected transgression; or a sufficiently clear separation between the financial interests of testing facilities and the manufacturers' choice of testing facilities.

[167] This requirement is already part of the Commission's proposal to repeal and replace Directive 2007/46/EC, complementing the Real Driving Emissions package. Source : http://europa.eu/rapid/press-release_IP-16-167_en.htm

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ANNEX 1 – CASE STUDY ON TYPE APPROVAL IN GERMANY

In Germany, the tests for type approval are carried out by technical service organisations on behalf of the national type approval authority – KBA (Kraftfahrtsbundesamt). Upon receipt of evidence of compliance with the regulations the KBA issues a type approval certificate to the manufacturer and the manufacturer can start to sell the car.

There are currently over 80 technical service organisations in Germany. They either provide the test laboratory and test the product, or provide the certification body and assess the quality management. Technical services are designated by the Dresden office of the KBA, and are published online[168]. Designated technical services must meet a number of criteria, generally following ISO standards169.

Testing can be carried out by the technical service provider at their own site or at the site of the manufacturer. A manufacturer pays for the testing and is free to choose any TAA and approved TS. The testing authorities thus compete for business enabling the carmaker to "shop around" for the optimal offer.

The technical service provider examines the vehicle following the test procedure, and draws up a report which is checked for correspondence with the manufacturer's description of the vehicle. The KBA then reviews the technical report and issues a type approval certificate when it has verified the conformity of the tests.

Following type approval the manufacturer can issue an unlimited number of that vehicle which correspond with that type approval. The manufacturer is responsible to ensure conformity of production (CoP) – which means that vehicles produced in that type following the specifications given in the type approval certificate.

The KBA can check the CoP of vehicles in production in two ways:

- Checking manufacturers records
- Checking approved vehicles

The law does not make provisions for further field investigations in order to detect inconsistencies in CoP. There is also no specification for reviewing type approval, i.e. by frequency or number of vehicles produced.

In the designation procedure (see box below), competence is confirmed for

Test laboratories:

To carry out or supervise tests, and draw up test reports for the type-approval procedure/CoP product checks of the KBA. The evaluation is carried out on basis of EN ISO/IEC 17025 and/or EN ISO/IEC 17020.

Certification bodies:

To evaluate the extent to which a quality management system conforms to approval-relevant requirements and to draw up corresponding attestations for the type-approval procedure/CoP

[168] For example http://www.kba.de/EN/Fahrzeugtechnik_en/Zum_Herunterladen_en/ErteilungTypgenehmigungen_en/verz_benannte_PL_pdf_dt_en.pdf?__blob=publicationFile&v=25

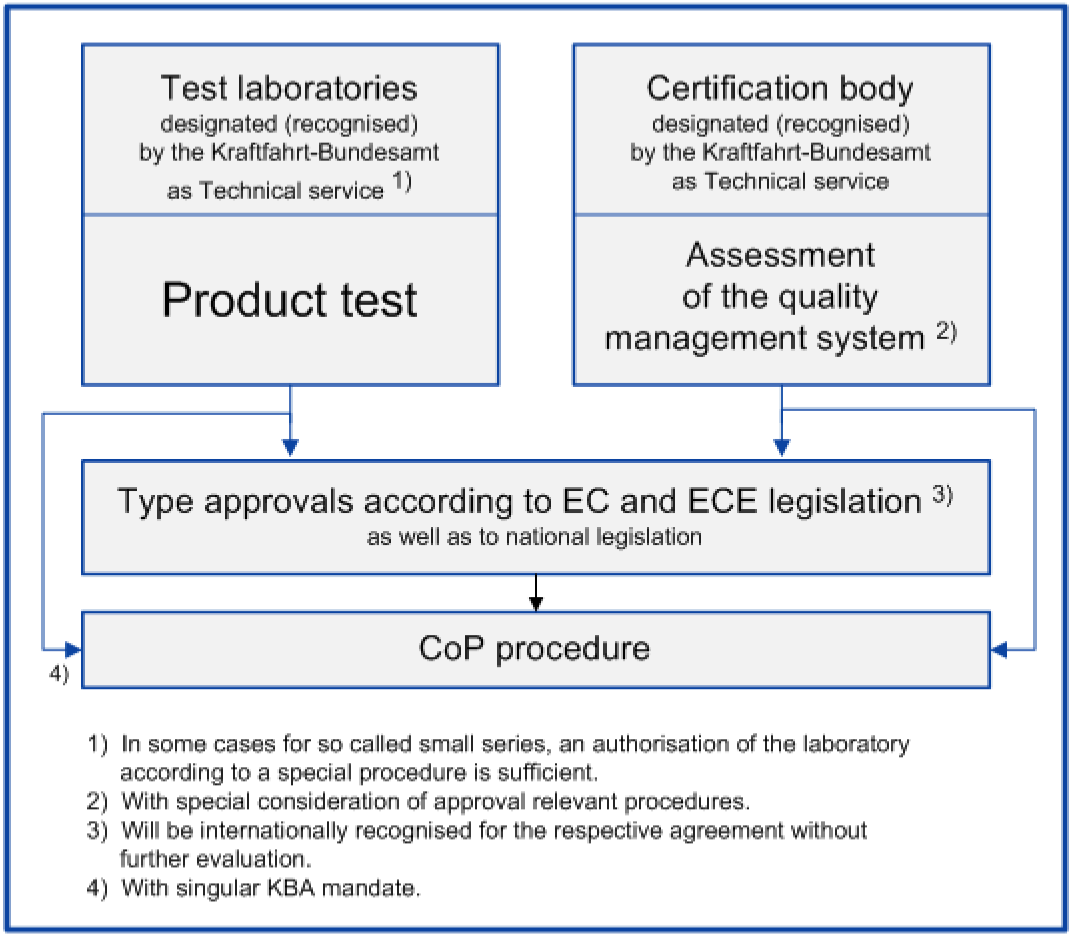
[169] For more information, please see http://www.kba.de/EN/Fahrzeugtechnik_en/Zum_Herunterladen_en/BenennungTechnischerDienste_en/benennungsregeln_PL_pdf_en.pdf?__blob=publicationFile&v=5

system evaluation of the KBA.Assessment is made on the basis of the EN ISO/IEC 17021 standard.

In connection with the EG-Fahrzeuggenehmigungsverordnung (EG-FGV), technical services will be recognised. Such recognition is synonymous with designation.

The designation (recognition) is coupled to the notification of the technical services to the European Commission and/or the UNECE secretary's office. In addition, designated technical services are published on the KBA internet page[170]. Testing Regimes in Germany currently follow the NEDC Procedure.

Designation of technical services



Source: KBA

[170] http://www.kba.de/EN/Fahrzeugtechnik_en/Typgenehmigung_en/Benennung_Technischer_Dienste_en/Benannte_Stellen_en/benannte_stellen_node_en.html

ANNEX 2 – US FEDERAL STANDARDS

Tier 1 Standards

Introduced in 1991 with a phase-in period running from 1994 until 1997, Tier 1 standards applied to all new passenger cars, light light-duty trucks (LLDT) with a gross vehicle weight rating (GVWR) of less than 6,000lbs, and heavy light-duty trucks (HLDT) with a GVWR of greater than 6,000lb but less than 8,500lbs that were manufactured within the phase-in period. Emissions performance was measured using the Federal Test Procedure 75 (FTP-75, see 'Testing' section for details) and specified over two timescales; shorter-term i.e. 5 years or 50,000 miles, whichever comes first and longer-term i.e. 10 years or 100,000 miles, whichever comes first (see Table 11).

Additional testing was introduced from 2000-2004 in order to address new standards for non-methane hydrocarbons (NMHC), NO_x and CO using a Supplemental Federal Test Procedure (SFTP) as shown below inTable 12. Standards at 50,000 miles/ 5 years are show in parentheses. NMHC and NOx emissions were often combined into one standard, but according to a California Air Resources Board (CARB) policy and procedures document, it is assumed that breakdown of emissions should be 5% and 95% respectively.

Table 11: Tier 1 emission standards for passenger cars and light-duty trucks, FTP, g/km

Category	50,000mi / 5 years						100,000 mi / 10 years*					
	THC	NMHC	CO	NOx** Diesel	NOx Petrol	PM***	THC	NMHC	CO	NOx** Diesel	NOx Petrol	PM***
Passenger cars	0.25	0.16	2.11	0.62	0.25	0.05	-	0.19	2.61	0.78	0.37	0.06
LLDT, LVW <3,750 lbs	-	0.16	2.11	0.62	0.25	0.05	0.50	0.19	2.61	0.78	0.37	0.06
LLDT, LVW >3,750 lbs	-	0.20	2.73	-	0.43	0.05	0.50	0.25	3.42	0.60	0.60	0.06
HLDT, ALVW <5,750 lbs	0.20	-	2.73	-	0.43	-	0.50	0.29	3.98	0.61	0.61	0.06
HLDT, ALVW > 5,750 lbs	0.24	-	3.11	-	0.68	-	0.50	0.35	4.54	0.95	0.95	0.07

* Useful life 120,000 miles/11 years for all HLDT standards and for THC standards for LDT
**More relaxed NOx limits for diesels applicable to vehicles through 2003 model year
***PM standards applicable to diesel vehicles only
LVW - loaded vehicle weight (curb weight + 300 lbs)
ALVW - adjusted LVW (the numerical average of the curb weight and the GVWR)

Source: DieselNet[171]

[171] DieselNet US Emissions Standards Summary, Tier 1 https://www.dieselnet.com/standards/us/ld_t1.php

Table 12: Tier 1 emission standards for passenger cars and light-duty trucks, SFTP, g/km

Category	NMHC+NOx	CO		
	Weighted	US06	SC03	Weighted
Passenger cars & LLDT, LVW <3,750 lbs	0.57/1.29** (0.40/0.92**)	6.90 (5.59)	2.3 (1.86)	2.61 (2.11)
LLDT, LVW >3,750 lbs	0.85 (0.63)	9.07 (7.21)	3.04 (2.42)	3.42 (2.73)
HLDT, ALVW <5,750 lbs	0.89(0.63)	10.50 (7.21)	3.48 (2.42)	3.98 (2.73)
HLDT, ALVW >5,750 lbs	1.30 (0.93)	11.99 (8.20)	3.98 (2.73)	4.54 (3.11)
** The more relaxed value is for diesel fuelled vehicles				

Source: DieselNet

Tier 2 Standards

Tier 2 standards, which are fuel-neutral thus applying equally to petrol, diesel and alternative-fuel vehicles, were agreed in 1999 with an implementation period running from 2004 until 2009. Tier 2 applies more stringent limitations on emissions from a wider range of vehicles including medium-duty passenger vehicles (MDPV) which are specified as being vehicles used for the purpose of personal transportation that have a GVWR of more than 8,5000lbs but less than 10,000lbs. Expecting such large vehicles to meet the same standards as smaller cars required them to have more advanced technologies to ensure compliance.

Two of the bigger changes to be introduced with the adoption of Tier 2 standards are ‘certification bins’ – essentially, emissions certification categories of different stringency - and fleet averages for NO_x emission levels. The ‘bins’ allowed manufactures to choose under which level of standard (with varying levels of stringency) to certify certain vehicles during a phasing-in period; however, the most-polluting categories (‘bins’) are then gradually phased out, with the allocation of vehicles to the remaining categories determining the process under which the manufacturer demonstrates overall fleet average compliance. For Tier 2 standards, the fleet average for NO_x states that by the end of the transition period (2009), a manufacturer’s entire fleet of light-duty vehicles must be a maximum of 0.04 g/km. Any vehicles that are above this limit for NO_x are known as ‘interim non-tier 2 standard’ vehicles, and must still meet the rest of the standards set out in one of the Tier 2 bins. The introduction of fleet average standards is said to “distinguish the US emission regulations from other light-duty emission standards for criteria pollutants across the world”[172].

In addition to these new requirements, Tier 2 standards also included specifications regarding fuel quality, namely the level of sulphur found in petrol. From 2004 petrol required a standard level of 120ppm, with a maximum of 300ppm. This was reduced further in 2006 when a maximum level of sulphur was specified as 80ppm, with a standard of 30ppm. These standards varied slightly across years and in different states. Legislation regarding sulphur in diesel has only been introduced for heavy duty engines.

[172] DieselNet, US Emissions Standards https://www.dieselnet.com/standards/us/ld.php

As with Tier 1, Tier 2 standards included supplemental testing for $NMHC+NO_x$ and CO emissions from passenger cars and light duty trucks (see Table 13). These standards were tested using the STFP US06 and SC03 driving cycles (see Testing section for details).

Table 13: Tier 2 supplemental emission standards for passenger cars and light-duty trucks, 4000 mile SFTP (g/km)

	US06		SC03	
	NMHC+NOx	CO	NMHC+NOx	CO
LDV/LDT1*	0.09	4.97	0.12	1.68
LDT2*	0.16	6.52	0.17	2.17
LDT3*	0.25	6.52	0.19	2.17
LDT4*	0.37	7.33	0.27	2.49
**different weight categories of passenger vehicles and light-duty trucks.*				

Source: DieselNet

Tier 2 also introduced the option of credits and deficits for NO_x emissions. Manufacturers, if producing vehicles and fleet with emission standards below that of the regulations, can bank credit for future use or trade with other manufactures. If a deficit is created, levels must be credited by another vehicle (be it 'in house' of by another manufacturer) within three years after the deficit was caused. Non-methane organic gases (NMOG), which are the diesel fuel equivalent of NMHC, credit can also be gained by a manufacturer.

Tier 3 Standards[173]

Tier 3 standards, which were adopted in 2014 for implementiation from 2017, tighten up on sulphur limits for petrol but follow the structure of Tier 2 standards with the certification bins (although they have been relabelled as the relevant 'NMOG+NOx' limit) and fleet average standards. Standards are also more stringent (see Table 14) and emission durability/ vehicle lifespan was also increased to 150,000 miles from 120,000 miles. Tier 3 standards are now in line with the California LEV III (see section on California standards for more information) standards to bring consistency on a national level. Tier 3 standards cover all new vehicles that fall into the categories of Tier 1 and Tier 2 as well as all heavy-duty vehicles with a GVWR of less than 14,000lbs.

Table 14: Tier 3 Certification bin standards, FTP

Bin	NMOG+NOx	PM*	CO	HCHO
	mg/km	*mg/km*	*g/km*	*mg/km*
Bin 160	99.42	1.86	2.61	2.49
Bin 125	77.67	1.86	1.30	2.49
Bin 70	43.50	1.86	1.06	2.49

[173] DieselNet US Emissions Standards Summary, Tier 3 https://www.dieselnet.com/standards/us/ld_t3.php

Bin	NMOG+NOx	PM*	CO	HCHO
	mg/km	*mg/km*	*g/km*	*mg/km*
Bin 50	31.07	1.86	1.06	2.49
Bin 30	18.64	1.86	0.62	2.49
Bin 20	12.43	1.86	0.62	2.49
Bin 0	0.00	0.00	0.00	0.00
* In MYs 2017-20, the PM standard applies only to that segment of a manufacturer's vehicles covered by the percent of sales phase-in for that model year, Table 11.				

Source: DieselNet

Whereas with Tier 2 standards fleet average standards for NO_x was static through the period of implementation, Tier 3 introduces fleet averages that reduce over time to ensure continual progression towards cleaner vehicles.

Table 15: Tier 3 fleet average standards for NMOG+NOx (mg/km)

Vehicle Category	2017*	2018	2019	2020	2021	2022	2023	2024	2025
LDV, LDT1	53	49	45	40	36	32	27	23	19
LDT2, LDT3, LDT4, MDPV	63	57	52	46	40	35	29	24	19
* For LDVs and LDTs over 6,000 lbs GVWR and MDPVs, the fleet average standards apply beginning in MY 2018.									

Source: DieselNet

In addition to fleet averages for NMOG+NO_x, there are supplemental NMOG+NO_x standards which are self-elected but must not exceed 112mg/km and fleet averages must meet the standards shown inTable 16.

Table 16: Tier 3 NMOG+NO and CO standards, SFTP

Emission	2017*	2018	2019	2020	2021	2022	2023	2024	2025
NMOG+NOx (mg/km)	64	60	56	52	48	43	39	35	31
CO (g/km)	2.6								
* For LDVs and LDTs over 6,000 lbs GVWR and MDPVs, the fleet average standards apply beginning in MY 2018.									

Source: DieselNet

Standards used to regulate particulate matter are now on a vehicle basis rather than fleet average. Two separate sets of standards have been issued, one using the FTP one using SFTP (US06 driving cycle).

Table 17: Phase-in schedule of Tier 3 PM standards for PM, FTP

	FTP, mg/km						SFTP, mg/km							
Phase-In	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Percentage of sales	20%*	20%	40%	70%	100%	100%	20%*	20%	40%	70%	100%	100 %	100%	100%
Certification standard	1.9	1.9	1.9	1.9	1.9	1.9	6.2	6.2	3.7	3.7	3.7	3.7	3.7	3.7
In-use standard	3.7	3.7	3.7	3.7	3.7	1.9	6.2	6.2	6.2	6.2	6.2	6.2	6.2	3.7

* Manufacturers comply in MY 2017 with 20% of their LDV and LDT fleet under 6,000 lbs GVWR, or alternatively with 10% of their total LDV, LDT, and MDPV fleet

Source: DieselNet

Petrol sulphur standards have also been made more stringent with a limit of 10ppm sulphur in federal petrol on an average basis by the start of 2017. Caps are higher at refineries and further ‘downstream’, with limits of 80ppm and 95ppm respectively.

Other provisions introduced by Tier 3 standards include:

- Evaporative emissions (0.3-0.5g per test for LDVs and MDPVs; 0.6g per test for petrol fuelled HDVs)
- On-Board Diagnostics (OBD)
- Direct Ozone Reduction (DOR)
- High Altitude Standards to account for different emissions at higher altitudes
- Emissions Averaging, Banking and Trading Program (ABT)

ANNEX 3 - CALIFORNIA STANDARDS

LEV Standards

As with the federal standards, California's LEV standards are fuel-neutral and apply equally regardless of a vehicle's fuel type. These standards differ from the EPA's regulations in the use of categories to specify the level of a car's cleanliness: Tier 1 (federal standard), Transitional Low Emission Vehicle (TLEV), Low Emission Vehicle (LEV), Ultra Low Emission Vehicle (ULEV), Super Ultra Low Emission Vehicle (SULEV) and Zero Emission Vehicle (ZEV). Upon introducing these standards in California in 1994, Tier 1 federal standards were the minimum requirement for vehicles within the state. After 2003 Tier 1 and TLEV standards were no longer applicaple, with LEV being the minimum standard moving forward. The LEV standards allow manufacturers to choose within which category to certify their vehicles but impose an obligation on manufacturers to steadily increase the proportion of their marketed vehicles which comply with the more rigorous categories throughout the phase-in period.

All light-duty and medium-duty vehicles must adhere to the 50,000 mile/5 year standards. However, the longer-term in-use standards differ slightly between the two classes of vehicles with medium-duty passenger vehicles having a longer lifespan of 120,000 miles or 11 years, whereas light-duty vehicles have a lifespan of 100,000 miles or 10 years. At this time, these vehicles are expected to meet the second set of standards which ensure the longevity of emissions standards in older vehicles.

Table 18: LEV Emission Standards for light-duty and medium-duty vehicles,FTP-75, g/km

Category		50,000 miles/5 years					100,000 miles/10 years (LDV)/ 120,000 miles/11 years (MDV)				
		NMOG[a]	CO	NOx	PM	HCHO	NMOG[a]	CO	NOx	PM	HCHO
Passenger cars	Tier 1	0.16	2.11	0.25	0.05	-	0.19	2.61	0.37	-	-
	TLEV	0.08	2.11	0.25	-	0.009	0.10	2.61	0.37	0.05	0.011
	LEV	0.05	2.11	0.12	-	0.009	0.06	2.61	0.19	0.05	0.011
	ULEV	0.02	1.06	0.12	-	0.005	0.03	1.30	0.19	0.02	0.007
LDT1, LVW <3,750 lbs	Tier 1	0.16	2.11	0.25	0.05	-	0.19	2.61	0.37	-	-
	TLEV	0.08	2.11	0.25	-	0.009	0.10	2.61	0.37	0.05	0.011
	LEV	0.05	2.11	0.12	-	0.009	0.06	2.61	0.19	0.05	0.011
	ULEV	0.02	1.06	0.12	-	0.005	0.03	1.30	0.19	0.02	0.007
LDT2, LVW >3,750 lbs	Tier 1	0.20	2.73	0.43	0.05	-	0.25	3.42	0.60	-	-
	TLEV	0.10	2.73	0.43	-	0.011	0.12	3.42	0.56	0.06	0.014
	LEV	0.06	2.73	0.25	-	0.011	0.08	3.42	0.31	0.06	0.014
	ULEV	0.03	1.37	0.25	-	0.006	0.04	1.74	0.31	0.03	0.008
MDV1 0-3750 lbs	Tier 1	0.16	2.11	0.25	-	-	0.22	3.11	0.34	0.05	-
	LEV	0.08	2.11	0.25	-	0.009	0.11	3.11	0.37	0.05	0.014
	ULEV	0.05	1.06	0.12	-	0.005	0.07	1.55	0.19	0.02	0.007
MDV2 3751-5750 lbs	Tier 1	0.20	2.73	0.43	-	-	0.29	3.98	0.61	0.06	-
	LEV	0.10	2.73	0.25	-	0.011	0.14	3.98	0.37	0.06	0.017
	ULEV	0.06	2.73	0.25	-	0.006	0.09	3.98	0.37	0.03	0.008
	SULEV	0.03	1.37	0.12	-	0.002	0.04	1.99	0.19	0.03	0.004
MDV3 5751-8500 lbs	Tier 1	0.24	3.11	0.68	-	-	0.35	4.54	0.95	0.07	-
	LEV	0.12	3.11	0.37	-	0.014	0.17	4.54	0.56	0.07	0.020
	ULEV	0.07	3.11	0.37	-	0.007	0.10	4.54	0.56	0.04	0.010
	SULEV	0.04	1.55	0.19	-	0.004	0.05	2.30	0.28	0.04	0.005
MDV4 8501-10,000 lbs	Tier 1	0.29	3.42	0.81	-	0.017	0.41	5.03	1.12	0.07	-
	LEV	0.14	3.42	0.43	-	0.017	0.21	5.03	0.62	0.07	0.025
	ULEV	0.09	3.42	0.43	-	0.009	0.12	5.03	0.62	0.04	0.013
	SULEV	0.04	1.74	0.22	-	0.004	0.06	2.55	0.31	0.04	0.006
MDV5 10,001-14,000 lbs	Tier 1	0.37	4.35	1.24	-	-	0.53	6.40	1.72	0.07	-
	LEV	0.19	4.35	0.62	-	0.022	0.27	6.40	0.93	0.07	0.032
	ULEV	0.11	4.35	0.62	-	0.011	0.16	6.40	0.93	0.04	0.016
	SULEV	0.06	2.17	0.31	-	0.006	0.08	3.23	0.43	0.04	0.008

a - NMHC for all Tier 1 standards

Abbreviations:
LVW - loaded vehicle weight (curb weight + 300 lbs)
LDT - light-duty truck
MDV - medium-duty vehicle (the maximum GVW from 8,500 to 14,000 lbs).
NMOG - non-methane organic gases
HCHO - formaldehyde

Source: DieselNet[174]

LEV II Standards

A few changes were made to LEV II standards including furthering standards to become more stringent, adjusting the categorisation of cars (based on weight), introduction of a 150,000 mile/15 year vehicle life span and the introduction of Partial Zero Emission Vehicle (PZEV).

Table 19: LEV II emissions standards for passenger cars and light-duty vehicles <8,500lb, FTP-75, g/km

Category	50,000 miles/5 years					120,000 miles/11 years				
	NMOG	CO	NOx	PM	HCHO	NMOG	CO	NOx	PM	HCHO
LEV	0.047	2.11	0.03	-	0.009	0.056	2.61	0.04	0.006	0.011
ULEV	0.025	1.06	0.03	-	0.005	0.034	1.30	0.04	0.006	0.007
SULEV	-	-	-	-	-	0.006	0.62	0.01	0.006	0.002

Source: DieselNet

Table 20: LEV II emissions standards for medium-duty vehicles, FTP-75, g/km

Weight (GVW)	120,000 miles/ 11 years					
	Category	NMOG	CO	NOx	PM	HCHO
8,500 - 10,000 lbs	LEV	0.195	6.4	0.2	0.12	0.032
	ULEV	0.143	6.4	0.2	0.06	0.016
	SULEV	0.100	3.2	0.1	0.06	0.008
10,001 - 14,000 lbs	LEV	0.230	7.3	0.4	0.12	0.040
	ULEV	0.167	7.3	0.4	0.06	0.021
	SULEV	0.117	3.7	0.2	0.06	0.010

Source: DieselNet

Regarding NO_x and PM regulations, the same standards were required to be met by all vehicles and engines, be they petrol, diesel or alternative fuel. LEVs and ULEVs that were classified as light-duty have a NO_x standard of 0.03g/km. LEV, ULEV and SULEVs that were classified as light duty have a PM standard of 0.006g/km for their entire life-span i.e. 120,000mi/11 years.

LEV III Standards

[174] DieselNet, Emissions Standards, USA, Cars and Light-Duty Trucks – California https://www.dieselnet.com/standards/us/ld_ca.php

LEV III Standards were adopted in 2012 for implementation between 2015 and 2025. These standards continued to progress towards even stricter regulations, in line with the federal Tier 3 standards.

Table 21: LEV III emission standards for passenger cars, LDTs and MDVs, FTP-75

Vehicle Type	Emission Category	NMOG+NOx	CO	HCHO	PM†
		g/km	g/km	mg/km	g/km
All PCs LDTs ≤ 8500 lbs GVW[a] All MDPVs	LEV160	0.10	2.6	2.5	0.006
	ULEV125	0.08	1.3	2.5	0.006
	ULEV70	0.04	1.1	2.5	0.006
	ULEV50	0.03	1.1	2.5	0.006
	SULEV30	0.02	0.6	2.5	0.006
	SULEV20	0.01	0.6	2.5	0.006
MDVs 8501 - 10,000 lbs GVW[b]	LEV395	0.25	4.0	3.7	0.075
	ULEV340	0.21	4.0	3.7	0.037
	ULEV250	0.16	4.0	3.7	0.037
	ULEV200	0.12	2.6	3.7	0.037
	SULEV170	0.11	2.6	3.7	0.037
	SULEV150	0.09	2.0	3.7	0.037
MDVs 10,001 - 14,000 lbs GVW[b]	LEV630	0.39	4.5	3.7	0.075
	ULEV570	0.35	4.5	3.7	0.037
	ULEV400	0.25	4.5	3.7	0.037
	ULEV270	0.17	2.6	3.7	0.037
	SULEV230	0.14	2.6	3.7	0.037
	SULEV200	0.12	2.3	3.7	0.037

† - Applicable only to vehicles not included in the phase-in of the final PM standards (Table 7 & Table 8).
a - Loaded vehicle weight (LVW)
b - Adjusted loaded vehicle weight (ALVW)

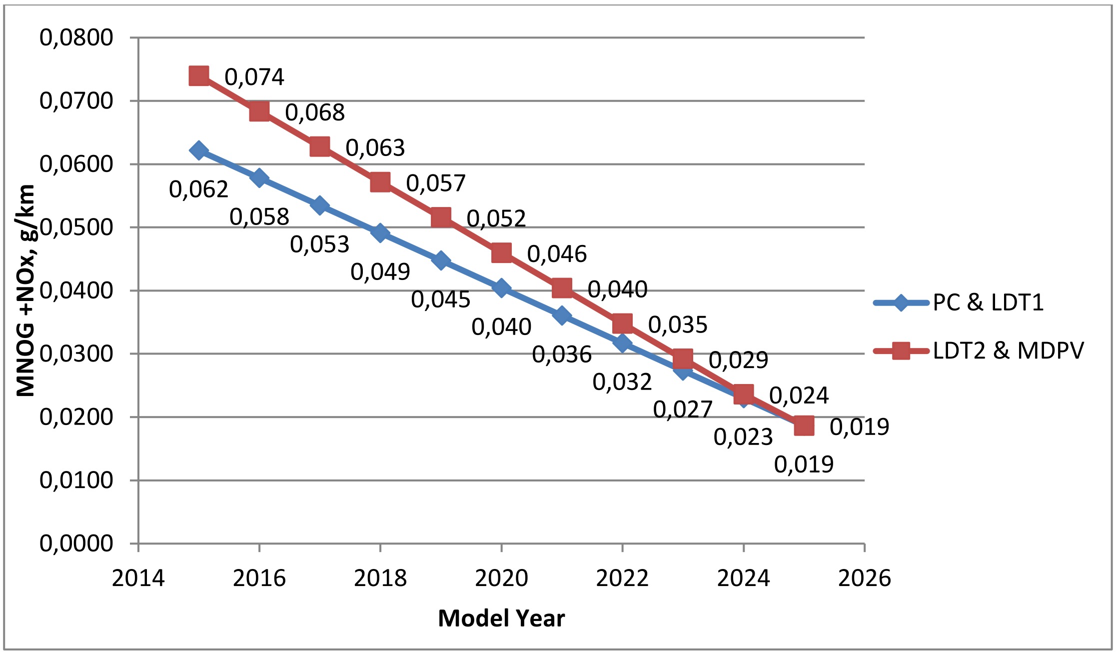
Abbreviations:
PC - Passenger car
LDT - light-duty truck
MDPV - medium-duty passenger vehicle
MDV - medium-duty vehicle

Source: DieselNet

LEV III standards include fleet average emission requirements relating to NMOG+NO_x which states that by 2025 the fleet average must be less than 0.019g018/km, with specified phase-in standards over the 10 year period.

As Figure 11 shows, manufacturers are required to gradually reduce the fleet average emissions of NMOG+NOx year-on-year. The 2025 standard for NMOG+NOx (0.019 g/km) reflects a 73% reduction on 2008 standards (0.07 g/km)[175]. For reiteration, LDT1 are light-duty trucks weighing between 0 and 3,750 lbs and LDT2 are light-duty trucks weighing between 3,751 and 8,500 lbs. Anything greater than the light-duty vehicle category do not have any fleet average standards.

Figure 11: NMOG+NO_x fleet average standards phase-in period 2015-2025



Source: DieselNet[176]

[175] DieselNet, Low Emission Vehicle III Standards (LEV III)
https://www.dieselnet.com/standards/us/ld_ca.php#leviii

[176] DieselNet, Low Emissions Vehicle III Standards (LEV III)
https://www.dieselnet.com/standards/us/ld_ca.php#leviii

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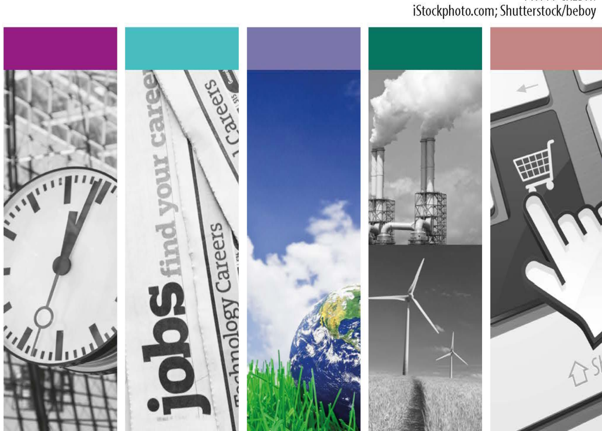

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