Supporting Analysis regarding Test Procedure Flexibilities and Technology Deployment for Review of the Light Duty Vehicle CO_2 Regulations

Service request #6 for Framework Contract on Vehicle Emissions

Framework Contract No ENV.C.3./FRA/2009/0043

Note on options for reducing test cycle flexibilities and their potential impact on type approval CO_2 emissions

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1 Introduction

1.1 Background

1.1.1 *Legislative context*

The purpose of the current EU regulatory framework on CO_2 emissions from light duty road vehicles is to reduce greenhouse gas (GHG) emissions from passenger cars and light commercial vehicles as a contribution to the EU's overall strategy to reduce its climate impacts. Regulation (EC) 443/2009 regulates CO_2 emissions from new passenger cars while Regulation (EU) 510/2011 regulates CO_2 emissions from new vans. These Regulations set limits based on average tailpipe CO_2 emissions from new vehicle sales. For passenger cars the average CO_2 emissions have to be lowered to 130 g/km in 2015 and to 95 g/km in 2020. For LCVs, the targets are respectively 175 g/km in 2017 and 147 g/km in 2020.

As a result of the (upcoming) regulation, as well as in response to other drivers such as fiscal incentives provided by various Member States to promote the purchase of fuel efficient vehicles, the average type approval CO_2 emission of passenger cars in Europe has decreased from 172 g/km in 2000 to 136 g/km in 2011.

1.1.2 *Indications of increased utilization of test flexibilities*

However, over the last few years indications have accumulated that part of the CO_2 emission reduction observed in the Monitoring Mechanism may not be attributable to the application of identifiable CO_2 reducing technologies. A preliminary evaluation in [TNO 2011] of 6 petrol and 6 diesel vehicle models sold in 2002 and 2009 suggested that some 9 - 10% of the reductions observed in that period could not be attributed to additional technologies applied to the assessed vehicle models between 2002 and 2009. [TNO 2011] suggested that this difference might to some extent be attributed to the application of small technical improvements, including improved calibrations, but that a large share of the difference might be the result of the increased utilisation of flexibilities in the test procedure. With utilisation of flexibilities in the test procedure we mean that by carefully selecting vehicle test conditions within, or possibly even outside, allowable bandwidths, manufacturers might be able to achieve reduced CO_2 emission levels on a given vehicle.

Obviously, reductions in type approval CO_2 emissions obtained in such a way not only affect the net impact of the regulation but also the costs of meeting the targets set for 2015 / 2017 and 2020. Due to a lack of hard evidence the possible effects of the increased utilisation of flexibilities could not be incorporated in the main cost assessment in [TNO 2011]. Instead the effect was included in a scenario variation for the cost curves. this scenario was found to lead to around € 600 lower costs per vehicle for meeting the passenger car target of 95 g/km in 2020, which is about one third of the costs estimated with cost curves based on application of headline technologies only.

The possible impact of increased utilisation of flexibilities is not only relevant from a regulatory point of view. Reductions on the type approval test that are not resulting from technological improvements to vehicles do not result in reduction of the fuel consumption in real-world driving. This means that vehicles do not deliver end-users the promised fuel cost reductions, leading to consumer misinformation. Consumer disappointment with real-world fuel consumption figures may ultimately lead to reduced support for the European CO_2 reduction policy as well as to fiscal and other stimulation policies in Member States. Also, varying levels of utilisation of flexibilities by different manufacturers may lead to unfair competition. Getting a clearer picture of this subject is therefore not only in the interest of the European Commission, but also in the interest of consumers, car manufacturers and Member State governments.

1.2 Flexibilities

Test cycle flexibilities are multiple parameters, related to the tested vehicle and conditions under which it is tested, that can be adapted during the type approval test, leading to changes in reported light duty vehicle CO_2 emissions. Different types of flexibilities can be distinguished, i.e.:

- Variations within bandwidths indicated in the test procedure;
- Variations with respect to test conditions and parameters not or not clearly specified in the test procedures ("it does not say that it is not allowed…");
- Variations outside allowed bandwidths.

The legislation allows manufacturers some leeway in preparing vehicles and carrying out tests, which has been utilised to a different extent by different manufacturers over time. The mere existence of flexibilities does not mean that they will all be fully deployed. There may be reasons why it is unattractive or impractical to use the full range.

For a detailed overview of all identified test flexibilities the reader is referred to [TNO 2012].

1.3 Main results from Service Request #6

This note is a deliverable from Service Request #6 of the Framework Contract on Vehicle Emissions (Framework Contract No ENV.C.3./FRA/2009/0043), in addition to the main report which is published separately [TNO 2012]. The study is intended to support the European Commission in its review of the light duty vehicle CO_2 regulations.

The main report for Service request #6 contains:

- a review of literature of applicable test procedures to identify test flexibilities and to estimate potential impacts of their utilisation on CO_2 emissions as measured on the type approval test;
- an assessment of the level of utilisation of such flexibilities over the last decade, based extensive consultation of type approval authorities and test houses;
- an estimation of the contribution of increased utilisation of test flexibilities to the reductions in type approval CO_2 emissions as observed over the last decade through the Monitoring Mechanism;
- a comparison of the estimated contribution from increased utilisation of test flexibilities and the estimated impact on average type approval CO_2 emissions of the increased deployment of CO_2 reducing technologies.

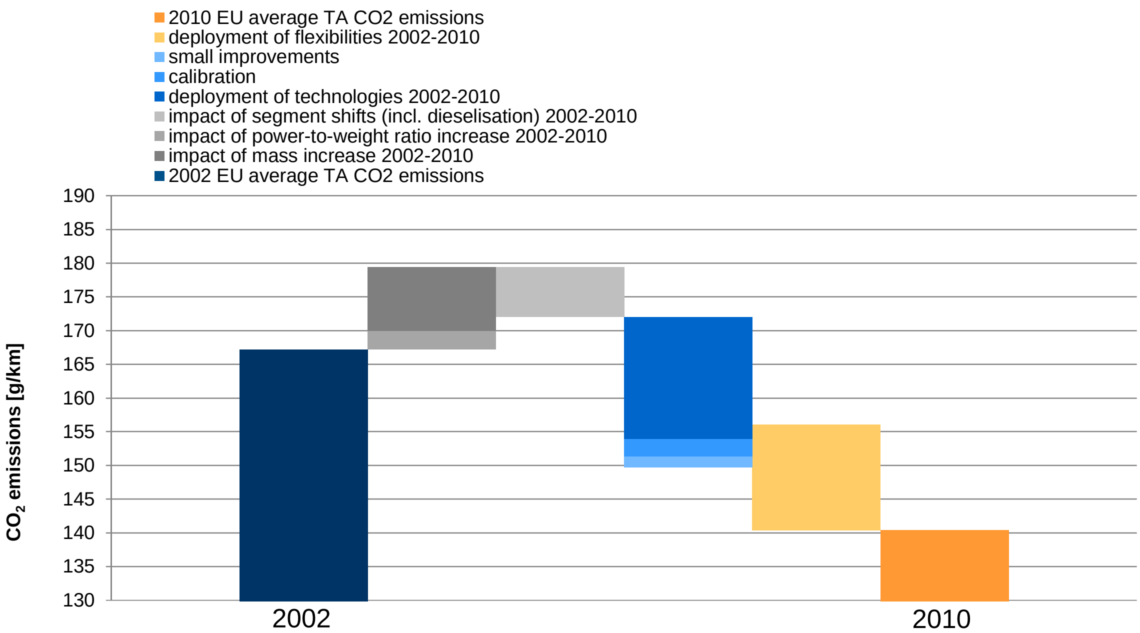

Figure 1 Graphical summary of the top-down and bottom-up analysis of the contributions of technology deployment resp. test cycle flexibilities to the reduction of passenger car CO_2 emissions observed between 2002-2010 (from [TNO 2012])

A confrontation of the results of a “top-down” analysis of impacts of technology deployment relative to the 2002 baseline and a “bottom-up” estimate of what the 2010 value would have been without the assessed impact of increased utilisation of flexibilities is presented in Figure 1.

Overall the conclusion is that Service request #6 has generated convincingly strong indications that the reductions in CO_2 emissions of light duty vehicles, as observed over the last decade, can be attributed to a combination of deployment of CO_2 reducing technologies, increased utilisation of test flexibilities and a range of smaller factors, including changes in vehicle characteristics which affect CO_2 emissions and shifts in sales between different size classes.

1.4 The purpose of this note

The purpose of this separate note is to identify options for reducing the potential impacts of utilisation of test flexibilities as well as for disincentivising the utilisation of remaining test flexibilities, and to recommend actions to be taken by the European Commission to further explore these options.

2 Options for reducing test cycle flexibilities and their potential impact on type approval CO_2 emissions

2.1 Introduction

The focus of Service Request #6 has been on identifying (the utilisation of) test flexibilities related to the existing type approval test procedures based on the NEDC test cycle. Based on the review presented in [TNO 2012] options can be identified for reducing test cycle flexibilities and their potential impact on CO_2 emissions as well as for disincentivising the utilisation of flexibilities.

Currently a new test cycle and associated test procedures for light-duty vehicles are being developed under UNECE auspices. In the development of this Worldwide harmonized Light vehicles Test Procedure (WLTP) explicit attention is paid to bandwidths in test conditions and other sources of test flexibilities. It is therefore expected that this new test procedure will reduce many of the flexibilities identified in this report. In view of the future adoption of the WLTP by the European Commission, however, it is useful to perform an explicit check on the extent to which the new procedure effectively reduces the potential impact of test flexibilities.

At this stage the WLTP is still under development, so that it is difficult to get an overview of which flexibilities have already been tackled by WLTP, let alone to judge whether the proposed improvements are sufficient. It is therefore recommended that the European Commission undertakes a review of the draft Global Technical Regulation (GTR) describing the WLTP to identify solutions already proposed by WLTP and possible remaining flexibilities that may need to be tackled by additional provisions to be added to the WLTP when it is adopted in European regulations.

In view of the above this note presents a set of options that could potentially be used for reducing the impact of test procedure flexibilities in current and future European light duty vehicle type approvals. It is recommended that the European Commission further explores these options in order to be able to either develop amendments to procedures proposed in WLTP or to develop add-on provisions which could be included in the adoption of WLTP in European type approval procedures.

2.2 General approaches

There are three main routes for reducing the potential impact of utilizing test cycle flexibilities on the CO_2 emissions reported from Type Approval:

- **Amending the type approval test procedures**, which has two main aspects:
  - **Narrowing the allowed bandwidths** for parameters specifying the test conditions.
    - These amendments would need to be included in the WLTP test procedure.
  - **Adding specifications** for parameters that are not or not well defined in the current test procedure.
    - These amendments would need to be included in the WLTP test procedure.
- **Developing correction methods** to compensate for the effects of variations within the allowed bandwidths.
  - These can be included in the WLTP test procedure, but could also be part of the way in which the WLTP test procedure is included in European type approval legislation.
  - In this note possible options for correcting test results are roughly sketched. In most case more study is necessary to develop concrete and practical methods.
- **Improvements in overall type approval legislation**
  - Another option to reduce the impact of utilizing test flexibilities is to introduce **In-Service Conformity** testing to make sure that CO_2 emissions measured on the Type Approval test are reproduced by production vehicles within a certain allowed tolerance band.
  - Alternatively additional provisions could be designed for **regulating in-use CO_2 emissions**, similar to what is under development for pollutant emissions.

- This will not only discourage the utilization flexibilities, but will also a minimize benefits of careful preparation of vehicles for the type approval test. The impacts of vehicle preparation are difficult to tackle through improved definition of the test procedures.

2.3 Considerations

The following chapters further describe specific options identified for the three main approaches, as described above, with the first two sections indicating options for improvement per type of flexibility as identified in [TNO 2012].

It should be noted that the identified options are first indications and ideas for possible solutions contributing to reducing the impact of test flexibilities, but that the practical feasibility of these options has not yet been explored in any detail.

The identified options for narrowing bandwidths in the test procedures are based on expert judgement, e.g. related to the improved capabilities of current, state-of-the-art test equipment. Before considering to apply such options further review and research is necessary e.g. to check to what extent narrowing down bandwidths and adding further specifications of test conditions affect the technical feasibility as well as costs of executing type approval testing.

3 Improving specifications of test conditions and narrowing bandwidths in the test procedures

3.1 Overview of relevant type approval test procedures

The procedure for measuring fuel consumption and CO_2 emissions, as part of European type approval testing, is defined in UNECE R101. While this procedure details specific aspects for measuring fuel consumption and CO_2 emissions, the main test procedure as such is defined in UNECE R83, which focusses on measurement of pollutant emissions. R83 details the test cycle to be used, requirements for the vehicle to be tested, as well as various conditions for the tests to be carried out.

The Type Approval test procedure consists of two main elements, being the actual emission test (also known as Type I test or NEDC test) carried out in a laboratory using a chassis dynamometer, and a “coast down” test to determine road load parameters that need to be simulated by the chassis dynamometer. Instead of using road load parameters determined from a coast down test manufacturer can choose to use so-called “cookbook” values. In that case chassis dynamometer settings are determined by applying a prescribed set of load terms, which are dependent on vehicle mass. The mass is looked up in the ‘cookbook’ or table in UNECE Regulation No. 83 (version 4), Annex 4A, Chapter 5, page 103 and the appropriate set of load terms read off and entered into the dynamometer control system. With this method there is no coast down matching as there is no target speed vs. time curve.

3.2 Coast-down testing

- **Test track design**
  The influence of test track design could be reduced by including more detailed specifications for the road surface of the test track, e.g. specifying surface material (concrete, asphalt) and smoothness. This may require development of a method to characterise road surfaces, but it is likely that methods for that can be borrowed from other research fields.
  The allowed slope of the test track could be reduced. With modern technology a slope of significantly less than 1.5% appears feasible. In relation to this aspect one could specify that the coast down tests in opposite directions have to be carried out on the same piece of track.

- **Wheel and tyre specifications**
  Instead of specifying that the widest tyre should be chosen, or the widest minus one in case more than three tyre sizes are available, the choice of tyres for coast down could be based on the coast down test result itself. The tyre with the shortest coast down time could be chosen (or the shortest minus one). This could require carrying out several coast down tests with different tyres before selecting the test result that is to be used for the laboratory testing. Alternatively the rolling resistance label (or other rolling resistance class definitions) could be included in selecting the worst-case or worst case minus one tyre for the test.

- **Preparation of the test vehicle**
  It could make sense to state more explicitly in the test procedure what is and is not allowed, e.g. in relation to taping of body parts, opening of the front cooling air inlet, vehicle body position (height / ground clearance), content of tyres, pre-treatment of brake pads, etcetera. The definition of the “standard vehicle” could be improved, and may need to be updated periodically in view of changes in “standard” fitting of equipment in newly sold vehicles. Regarding the tyres tighter specification of allowed variation in tread depth could be defined. Perhaps more explicit requirements can be formulated for the check by the type approval authority regarding whether the tyres used for coast-down testing are in “normal” conditions.

- **Tyre pressure**
  The influence of tyre pressure could be reduced by a tighter specification of the pressure set when the tyres are cold. Another option is to measure tyre pressures pre and post testing, and

specifying a maximum allowed difference. Alternatively a maximum value could be specified for the pressure of the warm tyres just before performing the coast down-test.

- **Test mass**
  A stricter definition of the vehicle configuration defining the kerb mass could be useful. In addition, to improve correlation with real-world driving, one could perform the coast down test with a specified percentage of the allowed payload. This value could be set at the average payload, or slightly higher in which case it would be used to compensate for flexibilities that are more difficult to tackle.

- **Brakes**
  In the quantitative analysis in this report of the impact of utilising test flexibilities the effects of eliminating parasitic drag by preparing the brake pads was not taken into account, due to lack of data necessary to quantify the effect. In principle, however, the effects of brake pad preparation are not negligible. Two approaches are possible: If the goal is solely to eliminate flexibilities, one could choose to explicitly allow brake pad preparation to eliminate parasitic drag. This would make sure that all vehicles are tested in the same way. From the perspective of improving correlation with real-world driving it would be preferable to define a procedure for using the brakes during the warming up of the vehicle. This would make sure that brake pads are in a more realistic configuration at the start of the coast down test. However, it will not be possible to eliminate vehicle-to-vehicle differences in this way.

- **Vehicle management systems:**
  For vehicles with automatic gear boxes application of a test mode could be allowed to make sure that the engine can be decoupled from the wheels in a specified way. Also for hybrids the powertrain configuration, in interaction with the vehicle management system, generally complicates the performance of a coast down test. Without appropriate provisions in the test procedure for how to deal with this, the solutions implemented by manufacturers may constitute a flexibility.

- **Ambient conditions**
  Reducing this flexibility would require improving definitions governing the validity of the test in relation to recorded wind speeds. But this is considered quite difficult. In the consultation type approval authorities and manufacturers indicated that the current wind speed conditions are challenging to meet, with much time being lost waiting for the wind to drop. For practical it is therefore not recommended to tighten the existing regulations. It might be worth undertaking some vehicle simulations to see whether running in opposite directions on the same piece of track might enable the wind speed limits to be relaxed a little, without introducing a “flexibility” that could be systematically exploited. In such a study the impact of wind angle could be investigated as well.

- **Other aspects of the coast down test**
  For other types of flexibilities associated with the coast-down test no options for reducing flexibilities or their impact on measured CO_2 emissions have been identified yet. Further study, however, is recommended.

3.3 Type I vehicle testing

- **Reference mass**
  The most important recommendation for this aspect is to reduce the width of the inertia classes. In principle inertia classes could be avoided altogether as modern chassis dynamometers allow continuous change of the inertia settings (stepless approach). For LD vehicles the inertia level in the current type approval test does not increase beyond 2270 kg for vehicles weighing above 2210 kg. This provision should be removed.

- **Wheel and tyre specifications**
  This issues is only relevant when cook-book values are used. Requirements for wheels and tyres in the type I test could be made the same as used for the coast down test. The rolling radius and tyre pressure could be specified more precisely.

- **Preparation of the test vehicle**
  It is recommended to explicitly forbid that the engine control system of a vehicle on a chassis dynamometer with open bonnet and/or non-moving wheels of the non-driven axle might be set in

a test mode which deviates from real world operation[1]. “Defeat devices” are difficult to prove so maybe an indirect approach would work better. An option for that is to define maximum allowed in-use emission levels (see under “Improvements to overall type approval legislation”). For hybrids and for correct operation of start-stop systems a solution needs to be developed. An allowed, well-specified test mode could be an option but is not preferred. The problem could be solved by always testing these vehicles on a 4-wheel chassis dynamometer. A general recommendation to reduce the impact of vehicle preparation is that it could be required that one sample (i.e. the same vehicle) should be used for the road load test and the emission test.

- **Running-in period of the test vehicle**
  The running-in period could be specified more tightly.
- **Laboratory instrumentation**
  The allowed bandwidth for the accuracy with which the coast down curve is replicated on the chassis dynamometer could be tightened. This may not be possible for older rollerbenches. In this case the deviation could be recorded and accounted for by a correction factor applied to the measured CO_2 result. Fixed Load Curve roller benches should be forbidden.
- **Fuel specifications**
  It is useful to consider tightening of the allowed variations in e.g. fuel density (kg/l), energy density (MJ/kg) and C/H ratio of reference fuels. For CO_2 emissions the carbon content (specifically the C/H ratio) in the fuel is leading. A reference and a correction method could be developed. Fuel properties should be recorded and reported.
- **Laboratory altitude**
  The impacts of laboratory altitude are not well-known, but are not necessarily negligible, This subject deserves further study.
- **Temperature effects**
  It is recommended to reduce the allowed temperature window from a 10^oC bandwidth ($20\text{-}30^oC$) to smaller bandwidth, e.g. 5 or 2^oC. This is not entirely straightforward because the temperature varies from place to place in the test room. Lubricant and coolant temperatures at the start of the test could be defined more precisely (e.g. 25 +/- 2°C). The test cell temperature during testing is less relevant. The median value could be defined closer to the European average ambient temperature. This is more for improving the representativeness of type approval value for real-world driving than for reducing flexibilities.
- **Coast down curve or cook-book values**
  In passenger car type approval nearly 100% of all type approvals are based coast down-tests. Especially for larger vans cook-book values are still used as these result in lower CO_2 values. For LD vehicles the dynamic coefficients (cook book values) do not change for vehicles weighing above 2610 kg. This provision should be removed. To promote aerodynamic improvements as a means to reduce CO_2, the use of cook-book values could be further discouraged. Cook-book values for vans could to be updated, so that default resistance factors are worse than real values for typical van configurations. Currently cookbook-values for passenger cars deviate in two ways: At lower speeds the cookbook-values are too low while at higher speeds they are too high.
- **Battery state-of-charge (for conventional vehicles)**
  It is at this stage difficult to propose solutions for this issue as the charging strategies are not well-known. It could be useful to introduce a restriction that the battery may be charged with an external charger before preconditioning, but that during preconditioning, soaking and testing battery charging would not be allowed.
- **Installation of the vehicle on the chassis dynamometer**
  Laboratory experience teaches that reproducibility is improved if the vehicle is tightened with tenterhooks which are horizontally mounted. The driven axis of the vehicle should be installed right above the centre of the roller.
- **Variation in gear shifting**
  Provisions for dealing with GSI and for gear box modes to be used are considered useful.

[1] Temperature sensors and engine speed and load traces can also be used to select an engine control strategy optimised to achieve low CO_2 emissions on the R101 test.

- **Declared CO_2 value**
  In order to avoid that it is applied to always lower the declared value relative to the measured value, it is recommended to either abolish the allowed 4% lowering of the measured CO_2 value, or improve the wording on how this tolerance may be applied. Currently the 4% is an allowed bandwidth for vehicles in the same family as the vehicle that is type approved. For CO_2, however, manufacturers do not define families, but rather carry out TA testing on all individual models. As a result the 4% can be used to define a lower TA value with the tested vehicle still complying as a “family member”.
- **Hybrid vehicles**
  It is recommended to improve the method for determining electric range. End-of-test criteria are fairly “sloppy”. It should be checked whether the amount of regenerative braking can be manipulated in range test, specifically in the last part of test when the vehicle rolls out after the end-of-test criterion is met. Alternatively one could decide not to allow the distance over which the vehicle rolls out to be included in the measured range. Type approval testing of HEVs should be performed on dual axle chassis dynamometers to avoid overestimation of the impact of regenerative braking. Also it is recommended to check whether the prescribed preconditioning of the battery SOC for the two tests to be performed on OVC hybrids contains significant flexibilities. Also it is recommended to review whether the definition of modes and prescribed modes to be used offer potential for test flexibility.
- **Other aspects of the emission test**
  For other types of flexibilities associated with the emissions test no options for reducing flexibilities or their impact on measured CO_2 emissions have been identified yet. Further study, however, is recommended.

3.4 Further issues

- **Multi-stage vehicles**
  For LCVs it is recommended to check whether the developments w.r.t. defining procedures for dealing with multi-stage vehicles offer potential test flexibilities.

4 Correction of impacts of variation in parameters defining test conditions

4.1 General approach

As an alternative for, or in addition to narrowing bandwidths in the procedures for coast down and laboratory testing, correction methods can be designed to reduce the impact of variations in parameters defining the test conditions. Such correction methods could be included in the WLTP, but could also be add-on provisions in the regulation governing the adoption of the WLTP for European type approval testing.

Developing such correction methods would require:

- defining reference test conditions, i.e. preferred central values for the test conditions for which variation within specified bandwidths is allowed;
- specifying that the actual test conditions are recorded and reported;
- determining formula's for correcting coast down test results and/or CO_2 emission values, measured under the actual conditions of the test, to what they would have been had the test been carried out under reference test conditions.

The review of possible impacts of various individual test flexibilities, as reported in chapters 2 and 3 of [TNO 2012] already provides some quantitative correlations that could be used as a starting point for developing correction methods.

4.2 Coast-down testing

- **Test track design**
  An option for reducing the impact of the test track slope is to introduce a requirement to record and report the sloping of the test track and to develop a correction method for translating the coast down test result to what it would have been on a flat track. A simplified approach could be to introduce a fixed malus factor for test tracks with a slope, which is used to correct the coast down curve. This malus factor could be chosen such that it effectively discourages the use of tracks with a slope higher than a given threshold.

- **Ambient conditions**
  Correction measures for air density (T, P) are already included in the present procedures. It is recommended to explore options for taking account of humidity in correction of deviations from standard air density conditions (T = 20^{o}C and P = 100kPa). Humidity changes the mass density and viscosity of air.

- **Other aspects of the coast down test**
  For other types of flexibilities associated with the coast-down test no options for correction methods have been identified yet. Further study, however, is recommended.

4.3 Type I vehicle testing

- **Reference mass**
  If inertia classes remain to be used, a 1st order correction could be developed for correcting the type approval test result for the impact of a difference between reference mass of the vehicle and the test mass used. The correction factor could be determined using a simple vehicle model containing the speed-time profile, the vehicle mass and the inertia settings. In this approach the powertrain efficiency is assumed constant, which is allowed for sufficiently small variations.

- **Fuel specifications**
  It is recommended to explore options for developing a method to correct for the impact of variations in e.g. fuel density (kg/l), energy density (MJ/kg) and C/H ratio on measured fuel consumption (l/100km) and CO_2 emissions.

- **Temperature effects**
  In this study a general / average correlation between test temperature and CO_2 has been derived, but given the complex interactions between vehicle and lab temperatures and engine performance, a simple correction formula may not be justified to correct results for individual vehicles. Our analysis finds that on average a 10^oC change in temperature leads to 1.7% change in CO_2. An average correction could be defined as follows: 25 °C is nominal, 20 °C = -1% and 30 °C = +1%, with steps of 0.2% for every ^oC in between. To be able to apply such a correction one needs to be specific about where this temperature is to be measured.

- **Battery state-of-charge**
  It is possible to measure the change in battery state-of-charge over the cycle and to correct measured fuel consumption and CO_2 emissions on the basis of an assumed combined engine-generator efficiency. This correction could be based on the R101 method for ΔSOC correction for NOVC hybrids.

- **Driving technique**
  The influence of deviations from the target speed (defined by the test cycle) within the allowed bandwidth could be corrected for in 1st order by recording the followed speed pattern and calculating the change in energy required at the wheels compared to when the cycle would be followed exactly. The correction factor could be determined using a simple vehicle model containing the speed-time profile, the vehicle mass and the inertia settings. In this approach the powertrain efficiency is assumed constant, which is allowed for sufficiently small variations.

- **Variation in gear shifting**
  Effects of gear box modes could be “corrected” by performing tests in all modes and averaging the result.

- **Other aspects of the emission test**
  For other types of flexibilities associated with the emission test no options for correction methods have been identified yet. Further study, however, is recommended.

5 Improvements to overall type approval legislation

In addition to the technical approaches described in the previous sections also regulatory approaches could be designed to reduce the impact of utilising test flexibilities. Instead of reducing the potential impacts of variations in test conditions inside or outside of allowed bandwidths, such regulatory approaches tend to discourage the utilisation of flexibilities inherent in the procedures.

The advantage of such a regulatory approach is that it will not only discourage the utilization flexibilities, but will also a minimize benefits of careful preparation of vehicles for the type approval test. The impacts of vehicle preparation are difficult to tackle through improved definition of the test procedures.

5.1 In-Service Conformity (ISC) for CO_2

An option to discourage utilisation of test flexibilities is to include a provision in the EU type approval regulation that allows the EU or Member States to perform spot checks on production vehicles, including an independently performed coast-down test. Measured values should not be allowed to exceed the TA CO_2 value provided by the manufacturer by more than x%. A similar provision could also be defined for the coast-down test only. Spot checks of production vehicles focussing on the coast-down test alone could also be relevant.

This option may still require tightening of various flexibilities in the test procedure (coast down and lab test) to avoid that the allowed deviation has to be very high, or, if the allowed deviation is small, to avoid disputes on the origin of observed differences between TA value and the ISC test result. The use of corrections for test parameter variations may help to improve correspondence between TA and ISC test results. In order to improve the quality of the test procedure for the determination of the road load a “round robin road load test program” could be useful.

5.2 Regulating In-use CO_2 emissions

Similar to what is discussed as a means to regulate pollutant emissions in real-world driving, maximum allowed in use emission levels for CO_2 could be set. For CO_2 this is probably more complicated than for pollutant emissions as CO_2 emissions fundamentally vary with driving pattern and driver behaviour. Also, for CO_2 it is not possible to set a single limit for all cars. The in-use limits need to be defined relative to the TA level en should probably be based on averages over a certain time. An option is to relate the limit to an estimate of the work delivered by the engine, which can be derived from the recorded driving pattern. It may not be possible to set the in-use maximum sufficiently close to the TA level.

6 Conclusion

This note is a deliverable of Service Request #6 of the Framework Contract on Vehicle Emissions (Framework Contract No ENV.C.3./FRA/2009/0043). The main report, which is published separately as [TNO 2012], concludes that increased utilisation of test flexibilities has contributed significantly to the reductions in type approval CO_2 emissions as observed over the last decade through the Monitoring Mechanism. This note has been developed to identify options for reducing the potential impact of utilizing test cycle flexibilities on the CO_2 emissions reported from Type Approval.

This note identifies three categories of options:

- **Amending the type approval test procedures**, which has two main aspects:
  - **Narrowing the allowed bandwidths** for parameters specifying the test conditions.
  - **Adding specifications** for parameters that are not or not well defined in the current test procedure.
- **Developing correction methods** to compensate for the effects of variations within the allowed bandwidths.
- **Improvements in overall type approval legislation**
  - Another option to reduce the impact of utilizing test flexibilities is to introduce **In-Service Conformity** testing to make sure that CO_2 emissions measured on the Type Approval test are reproduced by production vehicles within a certain allowed tolerance band.
  - Alternatively additional provisions could be designed for **regulating in-use CO_2 emissions**, similar to what is under development for pollutant emissions.

In this note specific options have been identified for the three main approaches, as described above, with the first two sections indicating options for improvement per type of flexibility as identified in [TNO 2012].

The European Commission is recommended to further explore the identified options. A first purpose of the list provided in this note is to evaluate the extent to which flexibilities are being effectively reduced in the development of the WLTP. A second purpose would be to serve as input for the development of provisions with respect to the adoption of the WLTP in European type approval and emission legislation.

It should be noted that the identified options are first indications and ideas for possible solutions contributing to reducing the impact of test flexibilities, but that the practical feasibility of these options has not yet been explored in any detail.

The identified options for narrowing bandwidths in the test procedures are based on expert judgement, e.g. related to the improved capabilities of current, state-of-the-art test equipment. Before considering to apply such options further review and research is necessary e.g. to check to what extent narrowing down bandwidths and adding further specifications of test conditions affect the technical feasibility as well as costs of executing type approval testing.

7 References

[TNO 2012] Supporting Analysis regarding Test Procedure Flexibilities and Technology Deployment for Review of the Light Duty Vehicle CO_2 Regulations, Service request #6 for Framework Contract on Vehicle Emissions (Framework Contract No ENV.C.3./FRA/2009/0043), carried out by TNO, AEA, Ricardo and IHS Global Insight on behalf the European Commission's DG CLIMA, December 5, 2012
See: http://ec.europa.eu/clima/policies/transport/vehicles/cars/docs