POLICY UPDATE

NOVEMBER 2013

WORLD-HARMONIZED LIGHT-DUTY VEHICLES TEST PROCEDURE (WLTP)

ICCT **POLICY UPDATES** SUMMARIZE REGULATORY AND OTHER DEVELOPMENTS RELATED TO CLEAN TRANSPORTATION WORLDWIDE.

On November 14, 2013, after four years of work, the formal text for the World-Harmonized Light-Duty Vehicles Test Procedure (WLTP) was adopted by the United Nations Working Party on Pollution and Energy (GRPE). The decision must be confirmed by the World Forum for Harmonization of Vehicles Regulations (WP.29) at its March 2014 session. If the WP.29 does confirm the GRPE decision, the WLTP will be complete and ready to be implemented by individual countries.

BACKGROUND

Regulations governing light-duty vehicle emissions and fuel consumption vary significantly across world regions and countries. Increasing numbers of vehicle models are being designed for global distribution and sold in many different markets and must comply with the different test procedures and standards in each one. Manufacturers face additional costs to certify their vehicles under several procedures and standards, even though the fundamental purpose of all regulations is essentially the same: to reduce pollutant emissions and improve fuel efficiency. Harmonizing the test methodology and the test cycle would reduce these costs to the benefit of both manufacturers and consumers. A harmonized approach would also make it easier to compare fuel efficiency and emission standards across regions and countries. Over time, this will improve the effectiveness of air quality targets and CO_2 reduction policies.

At its November 2007 session, the World Forum for Harmonization of Vehicles Regulations (WP.29) of the United Nations Economic Commission for Europe (UNECE) established an informal group under its Working Party on Pollution and Energy (GRPE)[1] to prepare a road map for the development of a world-harmonized light-duty vehicle test procedure (WLTP). This road map[2] was proposed in 2009 and called for the development of a Global Technical Regulation (GTR) for light-duty vehicles, similar to regulations developed earlier for motorcycles (GTR no. 2, WMTC)[3] and heavy-duty vehicles (GTR no. 4, WHDC).[4] A UN GTR specifies globally harmonized performance-related requirements

1 ECE/TRANS/WP.29/1064, para. 14, http://www.unece.org/fileadmin/DAM/trans/doc/2008/wp29/ECE-TRANS-WP29-1064c1e.pdf

2 ECE/TRANS/WP.29/2009/131, http://www.unece.org/fileadmin/DAM/trans/doc/2009/wp29/ECE-TRANS-WP29-2009-131e.pdf

3 ECE/TRANS/180/Add.2, http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29registry/gtr02.html

4 ECE/TRANS/180/Add.4, http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29registry/gtr4.html

and test procedures, but not the administrative provisions for certification by individual countries and their mutual recognition. Member countries ("contracting parties") that adopt the GTR are obliged to incorporate the GTR into their national laws.

After four years of development, the formal text for the first phase ("1a") version of the light-duty vehicle GTR was adopted by GRPE On November 14, 2013.[5]

The development of the WLTP comprised two main elements:

- Development of a harmonized driving cycle representative of world average driving conditions (internally referred to as the DHC)
- Development of a harmonized test procedure that sets the conditions, requirements, tolerances, etc. for the emissions test (internally referred to as the DTP)

Since the beginning of the WLTP process, the European Union had a strong political objective, set by its own legislation (Regulations (EC) 443/2009 and 510/2011), to develop and adopt a more realistic test procedure by 2014. This was a major driving factor for setting the time frame of phase 1 of the WLTP. Similarly, Japan has also agreed to adopt the WLTP for its fuel efficiency standards, and the existing Japanese 2020 efficiency target for new vehicles will likely be adjusted for the WLTP.

DEVELOPMENT OF A HARMONIZED DRIVING CYCLE

Driving cycles are an essential element for the measurement of fuel consumption and emissions. Currently, each region uses its own driving cycle, varying from a stylized, less dynamic driving pattern—*e.g.*, the NEDC in Europe—to a more dynamic driving pattern such as the US06 cycle used in the United States. The characteristics of a driving pattern, such as average speed, dynamic behavior, and length and number of stops, all have an effect on the resulting emissions and fuel consumption. Therefore, the best guarantee of realistic measurement results is to use a driving cycle that represents real-life driving conditions as well as possible. A more realistic driving cycle also helps ensure that improvements in fuel efficiency and emissions indicated by the certification test are representative of improvements under real-life driving conditions.[6]

Since the WLTP was intended to harmonize test procedures worldwide, the GRPE's task scope included development of a new cycle representing typical driving characteristics around the world. This is referred to as the World Harmonized Light-duty Vehicle Test Cycle, or WLTC. The real-world driving data used as input for this development came from five different regions: the European Union plus Switzerland, the United States, India, Korea, and Japan. This led to a database with more than 765,000 kilometers of driving data, covering a wide range of vehicle categories (vehicle segments, various engine capacities, power-to-mass ratios, manufacturers, etc.), road types (urban, rural, motorway) and driving conditions (peak, off-peak, weekend). Weighting factors were applied to adjust the collected data to the respective vehicle fleet mileages in each region. Next, the values of key vehicle emission characteristics were determined for the weighted database. In a complex automated process, combinations of "short-trips" from

5 GRPE-67-04-Rev.1, http://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grpe/GRPE-67-04-Rev.1.pdf

6 "From Laboratory To Road," www.theicct.org/laboratory-road.

this database were evaluated against these key characteristics values. The best matching combination became the new driving cycle, consisting of four phases with different speed distributions (low, medium, high and extra-high).

Three different driving cycles were developed representing three different vehicle classes, based upon a vehicle's power-to-mass ratio and its maximum speed. The figure below shows the speed pattern for a Class 3 vehicle, which is the highest power and speed class. This class is likely to cover the largest share of the world light-duty vehicle market. The length of the cycle was fixed at 1800 seconds (compare with 1180 seconds for NEDC, 1205 seconds for the JC08 cycle, and 1372 seconds for the FTP cycle). Two cycles for lower power/speed vehicles were also developed that eliminate the 4th hill (Class 1 and Class 2) and the 3rd hill (Class 1), as well as reduce the maximum acceleration rates and top speeds of the other hills.

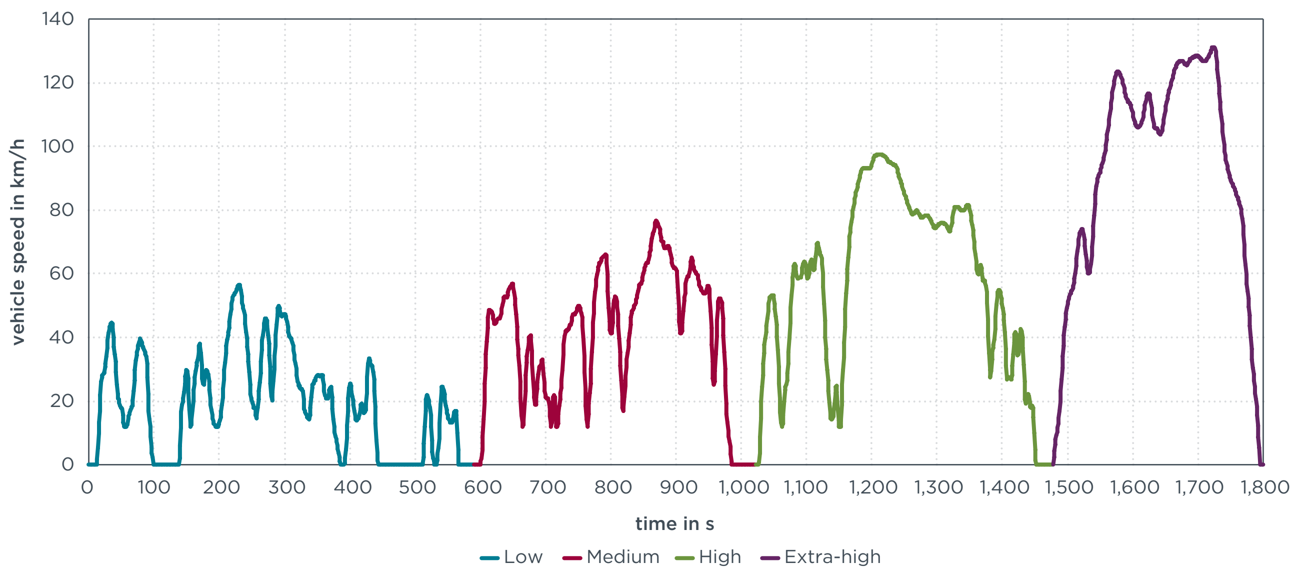

Figure 1. Speed pattern for Class 3 vehicles (power-to-mass >34 kW/ton, and top speed >120 km/h). The individual cycle phases (low, medium, high and extra-high) are colored respectively blue, red, green and purple.

In addition to development of the drive trace, a gearshift strategy for manual transmissions was established. This strategy simulates representative gearshift operation as a function of engine and vehicle characteristics. Automatic transmissions with driver-selectable modes must comply with emission standards in all modes, while the "predominant" mode should be used for efficiency testing.

The developed test cycle and the gearshift procedure were evaluated in several laboratories all over the world. The general conclusion was that the dynamics of the WLTC reflect the average real-world driving behavior of light-duty vehicles quite well. In addition, a good balance between representativeness of in-use driving data and drivability on the chassis dynamometer was found. However, the increase in fuel consumption compared to the NEDC was lower than expected. One explanation, among others, is the additional cold-start fuel consumption is being averaged over a larger distance and thus has a lower impact per km, due to the influence of the cycle length (WLTC: 1800 seconds, NEDC: 1180 seconds, JC08: 1205 seconds).

DEVELOPMENT OF A HARMONIZED TEST PROCEDURE

In addition to the driving cycle, a test *procedure* is needed to prescribe test conditions, requirements, tolerances, and so on. The procedure covers everything from the preparation of the test vehicle and measurement equipment to how the test is to be conducted and the results calculated. Development of the WLTP test procedure started by analyzing current emission statutes and regulations, along with related standards. The best features of each were identified and were used to pattern each section of the GTR.

Apart from the need for harmonization, there was also a common understanding that the test procedure should better represent normal driving conditions. Significant evidence exists that the gap between the reported fuel consumption from certification tests and fuel consumption during real-world driving has increased over the years.[7] The main drivers behind this growing gap are existing flexibilities in current test procedures and the introduction of fuel reduction technologies that show greater benefits during the existing cycles than on the road. Both issues are best addressed by a test procedure representing the conditions encountered during real-world driving. At the same time, this constraint may conflict with other important aspects of an emission test—namely, that it be practicable, reproducible, and cost-effective.

As a result of extensive analyses and discussions among the stakeholders, the WLTP GTR has managed to improve on many aspects of the existing emissions testing procedures. These include:

» The use of state-of-the-art measurement equipment with tightened tolerances and calibration techniques to take advantage of advancements in measurement technology (including NO_2 and N_2O emissions)

» More stringent requirements imposed on the test vehicle and test track used in determining representative road load (the road load value represents the total resistance to vehicle movement, and is used to set the power absorption unit of the chassis dynamometer)

» For each element of the test procedure the approach most representative of real-life conditions was selected, unless it fell outside the boundaries of being practicable, reproducible, and cost-effective

» New procedures were developed for measuring fuel/energy consumption and emissions of electric vehicles and hybrids, as well as the effect of other anticipated future drive train technologies, such as heat storage devices

» Improved methods to correct measurement results for parameters that affect fuel consumption and CO_2 emissions (*e.g.*, test temperature, vehicle mass, battery state of charge)

A number of important new concepts will also contribute to more realistic and objective test results. These include:

» Instead of declaring one CO_2 value for an entire family of vehicles (as currently required by EU legislation), each individual vehicle within a vehicle family

7 "From Laboratory To Road," www.theicct.org/laboratory-road.

will receive a CO_2 value based on its individual mass, rolling resistance, and aerodynamic drag, as determined by its standard and optional equipment.

- The test mass of the vehicle is raised to a more representative level. Also, instead of using discrete inertia steps[8], the simulated inertia corresponds exactly to the test mass[9].
- The difference in battery state-of-charge over the cycle is monitored and the fuel consumption corrected as needed based upon changes in battery state-of-charge over the cycle. Battery state-of-charge at the start of the test is changed from fully charged (NEDC) to a representative start value (the fully charged battery will be partially depleted by first driving a WLTC as preconditioning cycle).
- The test temperature in the laboratory is lowered from a range of 20˚C to 30°C to a set point of 23°C, and a temperature correction (to be developed) for the representative regional ambient temperature will be applied.
- Requirements and tolerances with respect to the road load determination procedure are strengthened and improved:
    - The test vehicle and tire specifications must be similar to those of the vehicle that will be manufactured.
    - Test tire preconditioning (tread depth, tire pressure, run-in, shape, no heat treatment allowed, etc.) will be more stringent, to more closely match the tire conditions on production vehicles.
    - Use of on-board anemometers will be permitted, and the correction method applied for wind during the coast-down method (both for stationary wind measurement as for on-board anemometry) is improved
    - Special brake preparation to avoid parasitic losses from brake pads touching brake discs will be prevented
    - Test track characteristics (*e.g.*, road inclination) will be more stringent to reduce positive influences on the road load determination.
- Instead of the "table of running resistances" (the "cookbook" of road load values that can be used if the road load for a vehicle has not been determined by track tests), a formula for calculating road load is provided, based on relevant vehicle characteristics.
- Means are provided to include the positive effect of heat storage/insulation in the soak procedure while ensuring that the benefit for in-use vehicles is similar.
- Electric and hybrid vehicles are separated from conventional vehicles with only an internal combustion engine, and dedicated test procedures have been developed for these vehicle types. Range, fuel/energy consumption, and emissions of electrified vehicles are defined in all-electric, charge-sustaining, and charge-depleting mode, and weighted by a utility factor (if applicable).

8 http://www.theicct.org/blogs/inertia-classes-vehicle-emissions-tests-and-dead-hand-past

9 http://www.theicct.org/sites/default/files/publications/WLTP4_2011.pdf

NEXT STEPS

With the adoption of the GTR in GRPE, the basic framework for a harmonized test procedure is now in place. The next regulatory step is for the WP.29 to confirm the regulation at their March 2014 session. Meanwhile, the contracting parties that adopt the GTR can start preparations to implement it into their national law. This process has already started in the EU, and a simulation-based correlation exercise has been initiated by the European Commission to convert the CO_2 targets set under the NEDC into targets for the GTR test procedure.

It is not certain that all contracting parties will adopt the GTR. The U.S., for instance, removed itself from the WLTP process early on, though it has continued to monitor developments. Contracting parties voting against the GTR have alternatives. They may continue to use their own law, or implement an amended version of the GTR. They could also decide to accept vehicles in compliance with the GTR of other contracting parties.

Not all of the issues that were raised during the development phase could be resolved. The remainder will be considered at subsequent GRPE and WP.29 sessions, until the first quarter of 2015[10]. Internally, this is referred to as "phase 1b". Some examples of remaining issues are:

- » Establish correction formulae to normalize measurement results to standard conditions, such as deviations from the speed trace, deviations in temperature, *etc*.
- » Provide requirements/specifications for wind tunnels to be used for the road load determination procedure.
- » Develop a supplemental test to correct for regional ambient temperature.
- » Resolve various issues concerning electric and hybrid vehicles (*e.g.*, calculation methods, dedicated CO_2, utility factor determination).
- » Develop measurement methods for ammonia, ethanol, and aldehydes.
- » Set speed-trace violation criteria and determine possible cycle downscaling if a vehicle cannot maintain the cycle speeds with wide-open throttle operation.

Since some of these issues are mainly driven by the European Commission (*e.g.*, the regional temperature correction and normalization of measurements), a possible outcome might be that those are not agreed by all contracting parties, but instead are implemented as so-called regional options.

The WLTP road map[11] specifies a phase 2 program at a later point of time, in order to address vehicle emissions under low ambient temperature and at high altitudes, as well as conformity issues such as emission durability demonstration, conformity of production (CoP), and in-service conformity testing (ISC). However, phase 2 of the WLTP is independent from the implementation of phase 1 into national law.

10 GRPE-67-06, http://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grpe/GRPE-67-06.pdf

11 ECE/TRANS/WP.29/2009/131, http://www.unece.org/fileadmin/DAM/trans/doc/2009/wp29/ECE-TRANS-WP29-2009-131e.pdf