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Addendum 15: United Nations Global Technical Regulation No. 15

Worldwide harmonized Light vehicles Test Procedures (WLTP)

(Established in the Global Registry on 11 November 2020)

Amendment 6 – Appendix 1

Proposal and report pursuant to Article 6, paragraph 6.2.7. of the Agreement

- Authorization to develop Phase 2 of UN GTR No. 15 (Worldwide harmonized Light vehicles Test Procedures (WLTP)) (ECE/TRANS/WP.29/AC.3/44).
- Technical report on the development of Amendment 6 to UN GTR No. 15 (Worldwide harmonized Light vehicles Test Procedures (WLTP)) (ECE/TRANS/WP.29/2020/128), adopted by AC.3 at its fifty-ninth session (ECE/TRANS/WP.29/1155, paras. 140-141).

UNITED NATIONS

GE.21-00597(E)

Authorization to develop Phase 2 of UN GTR No.15 (Worldwide harmonized Light vehicles Test Procedures (WLTP))

I. Background

1. The Informal Working Group (IWG) on Worldwide harmonized Light vehicles Test Procedures (WLTP) was set up in 2009. The original schedule and scope were described in ECE/TRANS/WP.29/AC.3/26 and Add.1. These documents outline WLTP activities and timeframe of each activity is divided into three phases (Phase 1 to Phase 3). The IWG submitted the United Nations Global Technical Regulation (UN GTR) on WLTP and it was adopted by the Working Party on Pollution and Energy (GRPE) as well as established by the World Forum for Harmonization of Vehicle Regulations (WP.29) and the Executive Committee of the 1998 Agreement (AC.3) in March 2014.

2. After the establishment in the Global Registry as UN GTR No. 15 in March 2014, ECE/TRANS/WP.29/AC.3/39 on the authorization to further develop the work on Phase 1b was adopted to solve the remaining issues of WLTP Phase 1a.

3. WLTP Phase 1b activities were completed and amendments to UN GTR No. 15 were submitted in October 2015 to be considered at the GRPE January 2016 session.

4. At the same time there is a need to transpose UN GTR No. 15 on WLTP into new Regulations annexed to the 1958 Agreement. The intended way forward for this task has been discussed several times at GRPE and it is described e.g. in informal document GRPE-72-18.

II. Proposal

5. An extension of the mandate for the WLTP IWG, sponsored by the European Union and Japan, shall tackle the development of the remaining issues. Phase 2 activities should be started immediately after the endorsement of this authorization by WP.29 and AC.3 at their November 2015 sessions.

6. Scope of work in Phase 2 should cover:

(a) Original items described in ECE/TRANS/WP.29/AC.3/26 and Add. 1 shall be kept;

(b) The remaining issues from WLTP Phase 1b;

(c) Durability for internal combustion engine vehicles and electric vehicles;

(d) Evaporative emissions;

(e) Low ambient temperature emissions;

(f) Test procedure for the determination of additional CO_2 emissions and fuel consumption from mobile air conditioning systems;

(g) On-board diagnostics requirements;

(h) Development of criteria for ex-post assessing of road load parameters (see WLTP-12-29-rev1e);

(i) Other items.

7. In addition, the IWG on WLTP shall work for the transposition of UN GTR No. 15 on WLTP into new Regulations annexed to the 1958 Agreement.

III. Timeline

8. The work of the IWG on WLTP Phase 2 should be completed by 2019. Phase 2 will be divided into Phases 2a (until June 2017) and 2b (until the end of 2019). The transposition of UN GTR No. 15 on WLTP into new Regulations annexed to the 1958 Agreement should ideally be finalized by the end of 2017 but the work may continue until the end of 2019 without a formal modification of this mandate, if needed due to circumstances.

9. A prolongation and extension of the mandate of the IWG on WLTP should be considered by GRPE in due time.

Technical report on the development of Amendment 6 to UN GTR No. 15 on the Worldwide harmonized Light vehicles Test Procedure (WLTP)

I. Mandate

1. Amendment 6 to UN GTR No. 15 was developed by the Informal Working Group (IWG) on Worldwide harmonized Light vehicles Test Procedures (WLTP) in the framework of Phase 2 of the development of UN GTR No. 15. The Executive Committee (AC.3) of the 1998 Agreement adopted the authorisation to develop Phase 2 of UN GTR No. 15 at its June 2016 session (ECE/TRANS/WP.29/AC.3/44).

II. Objectives

2. New definitions added for "Engine capacity" and "Engine displacement".

3. New definitions added to accompany the introduction of dual-axis dynamometer requirements in paragraph 2.4.2.4. of Annex 6.

4. New definition added for "Coasting" in association with an amendment to paragraph 2.4.2. of Annex 6.

5. New definitions added for Not Off-Vehicle Charging Fuel Cell Hybrid Vehicles (NOVC-FCHVs) and Off-Vehicle Charging Fuel Cell Hybrid Vehicles (OVC-FCHVs) to accompany the introduction of requirements for OVC-FCHVs which add to the requirements for NOVC-FCHVs which were already included in UN GTR No. 15.

6. Introduction of definitions for flex-fuel and mono-fuel vehicles to align with the UN Regulation No. [154] on WLTP and amendments included in Amendment 3 to UN GTR No. 19.

7. Update to the definition for "defeat device", accompanied by new text in paragraph 5.5.5. of the UN GTR. to align with the definition and supporting paragraph included in UN Regulation No. [154].

8. Introduction of a new definition for "Configurable start mode" to support amendments to the requirements of the UN GTR in paragraph 2.6.6. of Annex 6.

9. Introduction of new definitions on the topic of On-Board Diagnostics (OBD) to support the new annex for OBD (Annex 11).

10. Introduction of new family definitions to cover the amendments and additions introduced in Amendment 6 to UN GTR No. 15, covering OVC-FCHV and NOVC-FCHV interpolation families; Gas Fuelled Vehicles (GFV) family; Exhaust after-treatment system using reagent (ER) family; OBD family; Durability family; Low temperature family; and K_{CO2} correction factor family for OVC-HEVs and NOVC-HEVs.

11. The annexes concerning the WLTC (Annex 1), and gear selection and shift point determination for vehicles equipped with manual transmissions (Annex 2) were updated to resolve issues which were encountered through the implementation of regional WLTP legislation and to introduce machine code versions of the calculation tool, which will be available on the UNECE website.

12. Annex 3 was updated to introduce new reference fuel specifications for the new Type 6 Low Temperature test that was added to UN GTR No. 15 in a new optional Annex 13. These were introduced in Part II of Annex 3, with a new Part I having been created for the Type 1 test reference fuels. In addition to the new reference fuels for the Type 6 test, a new Type 1 test reference fuel was introduced to align with the harmonised diesel (B5H) reference fuel which were included in Level 2 of UN Regulation No. [154] (the most stringent level). Relevant sections of Annex 6 and Annex 7 were also updated to introduce this new fuel.

13. To align with UN Regulation No. [154], new requirements were added in relation to the testing of 4WD vehicles, which are required to be tested on a dual-axis dynamometer. These requirements were introduced in a new paragraph 2.4.2.4. of Annex 6 (Allocation of dynamometer type to test vehicle), with other related amendments being made in paragraph 3 (definitions), and Annex 4 (paragraph 2.5.3. and 7.3.3.), Annex 5 (paragraph 2.3.) and Annex 6 (paragraphs 2.4.2.4. and 2.6.3.2.); As a result of the discussions in the Dual-Axis Dyno Task Force and the main Informal Working Group the requirements of paragraph 7.3.3. of Annex 4 relating to the placement of the vehicle on the dynamometer were updated in relation to vehicle restraint during testing, to ensure that there can be no vertical force applied. The provisions of paragraph 2.4.2.4. of Annex 6 require 4WD vehicles to be tested on a dual-axis dyno unless equivalency between a dynamometer in 2WD operation and a dynamometer in 4WD operation can be demonstrated to the responsible authority – based on a set of conditions specified in paragraph 2.4.2.5.1. of Annex 6.

14. Interpolation method and minimum deltas - paragraph 4.2.1.1.2. of Annex 4; The interpolation method contains a minimum delta of 5 mg/km CO_2 in order to avoid perverse effects due to test to test variability but it has been noticed that similar effects can occur when the individual coefficients f_0, f_1 and f_2 lie too close together and are then extrapolated. New rules have been developed to eliminate this effect.

15. Clarification that for vehicles supplied with an additional set of snow tyres (with or without wheels) these shall not be considered as optional equipment when determining the cycle energy demand. This clarification has been provided in paragraph 4.2.1.1.2. of Annex 4 and also in several paragraphs of Annex 7.

16. Amendments were made to the provisions in Annex 4 for flat belt measurement (paragraph 6.5.2. of Annex 4) to introduce an option for cases where the air drag coefficient of a vehicle is not constant over speed.

17. A new paragraph 2.3.2. of Annex 5 was added to provide the requirements relating to the vehicle restraint system for single roller chassis dynamometers.

18. The requirements for measuring Particle Number (PN) have been updated by the work of the IWG on Particulate Measurement Protocol (PMP) , introducing new test equipment requirements for a solid particle number measurement procedure with a cut-off size of approximately 10 nm (SPN10) and also updating the existing requirements for measurement with a cut-off size of 23nm (SPN23), in particular allowing the use of a catalyzed evaporation device in volatile particle remover (VPR). These amendments, along with the technical rational are provided in Appendix 1 to this Technical Report.

19. Additional provisions relating to Type 1 testing of vehicles fuelled with LPG or NG/biomethane have been introduced in paragraph 1.1.2. of Annex 6. These reflect the requirements introduced in UN Regulation No. [154], which were themselves based on the provisions of Annex 12 of UN Regulation No. 83.

20. UN GTR No. 15 has been updated in multiple locations to align with UN Regulation No. [154] in relation to the addition of a Contracting Party option for the calculation and declaration of ‘fuel efficiency’ (km/l) as an alternative to fuel consumption (l/100km) and CO_2. In many areas of the UN GTR, the first instance being paragraph 1.2.3.3. of Annex 6, two options for the requirements are provided. Option A relates to the 4-phase WLTP, as required by Level 1A of UN Regulation No. [154], whilst Option B covers the results after the first 3 phases of a WLTP test, as required by Level 1B of UN Regulation No. [154]. The introduction of the fuel efficiency metric has resulted in updates throughout Annex 6, Annex 7 and Annex 8, as well as in the new Annex 14 covering Conformity of Production.

21. The introduction of optional requirements relating to OVC-FCHV, in Level 1A of UN Regulation No. [154], has also resulted in multiple changes in the UN GTR. Whilst the majority of these are included in Annex 8 and its appendices, there are other areas of the UN GTR where requirements relating to OVC-FCHV are included, e.g. an additional element in Table A6/2. The procedure described and defined for OVC-FCHV is following the procedure from Off-Vehicle Charging Hybrid Electric Vehicles (OVC-HEVs), but adjusting it to the requirements from OVC-FCHVs (e.g. replacing fuel consumption by

hydrogen consumption). Besides the procedure for OVC-FCHVs, the interpolation approach for those vehicles has been introduced (along with a family definition). Interpolation approach was also added for NOVC-FCHVs.

22. Paragraph 2.3.2.4. of Annex 6 and paragraph 4.5.1.1.5. of paragraph 8 have been updated to clarify how to verify the linearity of CO_2 mass emissions for vehicle M, both for a 4-phase calculation and a 3-phase calculation.

23. Paragraph 2.4.2. of Annex 6 has been updated to provide a Contracting Party option relating to vehicles fitted with a coasting functionality. This option requires that the functionality shall be deactivated during chassis dynamometer testing. The introduction of this modification was supported by the introduction of a new definition for "coasting" in paragraph 3 of this UN GTR.

24. Paragraph 2.6.6. of Annex 6 (Driver selectable modes) has been updated to provide clarification. This update introduces the new term "configurable start mode" which has been introduced as a new definition in paragraph 3 of the UN GTR. This covers the situation where some modes are retained after a “key off” but others default back to a mode similar to a predominant concept.

25. Paragraph 2.6.8.3. of Annex 6 (Speed trace tolerances) has been updated and restructured to include requirements for Inertial Work Rating (IWR) and Root Mean Squared Speed Error (RMSSE) which were previously included in paragraph 7. of Annex 7. Amendments throughout paragraph 7. of Annex 7 have been made in order to align with the changes made in paragraph 2.6.8.3. of Annex 6.

26. Paragraph 3. of Appendix 2 to Annex 6 (Rechargeable Electric Energy Storage System -REESS- energy change-based correction procedure) has been updated. Paragraphs 3.4.2., 3.4.3. and 3.4.4. have been replaced by a new paragraph 3.4.2. This aligns the requirements for conventional (ICE) vehicles more closely with those for electrified vehicles and simplifies the text considerably by eliminating the need to calculate the coefficient 'c'. In addition, Table A6.App2/1 Energy content of fuel has been updated to introduce heat values for LPG and CNG, as well as to introduce the B5H harmonised diesel reference fuel.

27. The post-processing tables in Annex 7 and Annex 8 have been updated to align with the tables finalised for UN Regulation No. [154], with some additional modifications and corrections to those tables of UN Regulation No. [154], and new tables have been added to cover the introduction of requirements for OVC-FCHVs into the UN GTR (Tables A8/9a and A8/9b). In addition, underneath the table captions clarification is provided to explain that in order to calculate the results for 3-phases and 4-phases the tables must be worked through twice, once for the 3-phase and once for 4-phase.

28. In relation to Table A7/1 (Procedure for calculating final test results), at the 30th IWG on WLTP a discussion was held on the provisions for the calculation of phase specific fuel consumption; The calculation of the phase specific fuel consumption in the WLTP is based on the phase specific CO_2 result, while for CO and HC the total test results are used. It was explained that the reason for this is that when having a regenerating exhaust aftertreatment system the K_i factors will be applied. K_i factors are only available for the whole test results. Therefore in order to avoid too much test burden it was accepted as a technical compromise. The effect might be only a few tenths of a percent.

29. Paragraph 3.2.1.1.4. of Annex 7 (Flow-weighted arithmetic average concentration calculation) was updated to correct an anomaly which had been uncovered in the UN GTR which is confusing and can also adversely affect the accuracy of the mass calculations for continuous dilute measurements from the constant volume sampler (CVS).

30. Through the work of the Computational Fluid Dynamics (CFD) Task Force the requirements of paragraph 3.2.3.2.2.3.2. of Annex 7 (Alternative method for determination of aerodynamic influence of optional equipment) was updated. This includes CFD simulation as a Contracting Party option.

31. The method allows the use CFD simulation software to determine the $\Delta C_d.A_f$ of aerodynamic optional equipment instead of using the windtunnel method. There are

restrictions specified with respect to the scope (in terms of applicable vehicles and type of optional equipment), the accuracy of the simulation software and the maximum allowed $\Delta C_d.A_f$.

32. Before the CFD simulation software may be used, the manufacturer shall demonstrate the equivalency of the method by a validation test programme in a windtunnel for at least two types of optional equipment, and may then only be applied for those types of optional equipment (e.g. wheels, cooling air control systems, spoilers, etc.).

33. Annex 8 of the UN GTR has been amended in multiple locations to introduce the requirements for fuel efficiency (see paragraph 20 of this Technical Report) and OVC-FCHVs (see paragraph 21).

34. Topics related to the Annex 8 vehicles (covered by Annex 8 of the UN GTR) have been amended in multiple locations as follows:

(a) Interpolation family criteria of OVC-HEVs and Pure Electric Vehicles (PEVs) (Main Body of the UN GTR) for all levels: Updated regarding charge electric energy converter, type of traction REESS.

(b) Added CO_2 correction factor family (Main Body of the UN GTR) for UN Regulation No. [154] Level 1A equivalent: Required for application of CO_2 correction factor family.

(c) Exempt humidity requirements for PEVs and FCHVs (paragraph 3.1.3.) for all levels: Not necessary for PEVs and FCHVs.

(d) Calculation schemes in Annex 8, Chapter 4 for all levels: Change of input parameters for calculation schemes of $M_{CO2,weighted}$, $FC_{weighted}$, $EC_{AC,weighted}$, EAER from measured values (partially) to declared values (completely). Further clarification and adjustments where identified.

(e) Post Processing Tables in Annex 8, Chapter 4 for all levels: Error correction of errors identified by lessons learned.

(f) Option to decrease EAER and $EAER_p$ as a manufacturers option (Annex 8, Chapter 4): Manufacturer is allowed to decrease the range values of EAER and $EAER_p$.

35. CO2 correction (Annex 8, Appendix 2):

(a) Clarification of its application in paragraph 1 for all levels

(b) CO_2 correction factor family application in paragraph 2.1. for level 1A: The correction factor determined for one interpolation family can be applied to other interpolation families when meeting the requirements of the CO_2 correction factor family.

(c) Generic approach application in paragraph 4 for all levels: A new paragraph 4 has been added to Appendix 2 to Annex 8 which introduces a manufacturer's option for an alternative test procedure for rechargeable electric energy storage system monitoring.

36. Paragraph 3 of Appendix 3 to Annex 8 ("REESS voltage application") for all levels: Paragraph 3 was reworked due to the nominal voltage application.

37. Charging of OVC-HEVs and PEVs in Annex 8, Appendix 4 for all levels: In paragraph 3.1.2., information was added regarding the soaking and application of the normal charge.

38. In Appendix 6 to Annex 8, the concept of configurable start mode has been added for all vehicle types described in Annex 8 and for all levels.

39. In addition a new Appendix 8 has been added to Annex 8 relating to the calculation of additional values required for checking the Conformity of Production of electric energy consumption of PEVs and OVC-HEVs. This has been moved from the calculation part in the context of CoP to this annex as the calculation of these specific value already need to be performed during type approval for vehicle high and vehicle low. Furthermore, the interpolation of these CoP values is described in Appendix 8.

40. Amendment 6 to UN GTR No. 15 introduces a new Annex 10 covering the requirements for vehicles that use a reagent for the exhaust after-treatment system. These requirements have been copied from UN Regulation No. [154], which in turn had been copied from Appendix 6 to UN Regulation No. 83.

41. For UN GTR No. 15 the requirement in paragraph 8.3.4. of Annex 10, relating to a ‘performance restriction’ approach to restrict the speed of the vehicle after the inducement system activates has been made a Contracting Party option to align with Level 1B of UN Regulation No. [154].

42. Amendment 6 to UN GTR No. 15 introduces a new Annex 11 covering provisions relating to On-Board Diagnostics (OBD); The OBD procedure from Annex 11 of the 07 series of amendments to UN Regulation No. 83 was updated for inclusion in the new UN Regulation No. [154], introducing the WLTC in place of NEDC and also incorporating Japan’s OBD provisions (for example the use of a 3-phase versus 4-phase WLTC). There was also some clarification of provisions including additional definitions.

43. For Amendment 6 to UN GTR No. 15 the text describing the OBD procedure in UN Regulation No. [154] has been further refined by some restructuring of the provisions and the inclusion of some additional definitions to those in UN Regulation No. [154].

44. Amendment 6 to UN GTR No. 15 introduces a new optional Annex 12 covering provisions relating to the Type 5 test (Description of the endurance test for verifying the durability of pollution control devices).

45. Annex 12 introduces the new provisions around the 07 series of amendments to UN Regulation No. 83 Type 5 test requiring emissions testing on WLTC which were developed for inclusion in UN Regulation No. [154] and including the specific regional requirements of the EU and Japan as Contracting Party options.

46. Option A is based on the EU provisions in terms of useful life (160,000 km), assigned DFs and acceptable mileage accumulation procedures, allowing the use of component bench ageing.

47. Option B is based on the Japan provisions in terms of useful life (80,000 or 60,000km), assigned DFs and acceptable mileage accumulation procedures, but excluding the use of component bench ageing.

48. Amendment 6 to UN GTR No. 15 introduces a new optional Annex 13 covering provisions relating to the Type 6 test (Low temperature test)

49. Unlike the other new annexes introduced in Amendment 6 to UN GTR No. 15, the Type 6 test is not included in UN Regulation No. [154].

50. The WLTP based Type 6 test included in Annex 13 differs in many areas from the NEDC based Type VI test included in Annex 8 to the 07 series of amendments to UN Regulation No. 83, including the scope of vehicles covered and the test requirements. Appendix 2 of this Technical Report provides a detailed explanation.

51. Amendment 6 to UN GTR No. 15 introduces a new optional Annex 14 covering provisions relating to Conformity of Production (CoP).

52. The CoP provisions were developed by the Conformity of Production Task Force for inclusion in UN Regulation No. [154] and have now been copied into the UN GTR, as appropriate. These integrate the EU and Japan CoP provisions, with Contracting Party options providing the alternative provisions.

53. Appendix 3 to this Technical Report provides details of the CoP provisions.

III. Meetings held by Task Forces

54. The proposed changes in Amendment 6 to UN GTR No. 15 listed in section II above were discussed at length and agreed upon by all participants during the following IWG meetings:

(a) 26th IWG, April 2019 (Zagreb);

(b) 27th IWG, May 2019 (Geneva);

(c) 28th IWG, September 2019 (Bern);

(d) 29th IWG, January 2020 (Geneva)

(e) Intermediate IWG, February 2020 (Brussels)

(f) 30th IWG, April 2020 (Remote WebEx)

55. Numerous face-to-face or audio/web meetings of the following task forces were held: electric vehicle (EV); Gearshift; CFD; Drive Trace Indices; Dual Axis Dyno; Low Temperature; Drafting Subgroup; Durability; Conformity of Production; and OBD.

Appendix 1

I. Technical report from the Informal Working Group (IWG) on Particle Measurement Programme (PMP)

1. This appendix is prepared by the Informal Working Group (IWG) on Particle Measurement Programme (PMP) to inform and update the GRPE of the work of the IWG on the Amendment 6 to UN GTR No. 15 Annexes 5, 6 and 7 to:

(a) Modify the existing solid PN measurement methodology having a 50% cut-off size at 23 nm (SPN23) in order to allow the use of catalyzed evaporation device in volatile particle remover (VPR) and introduce minor improvements

(b) Include as a second alternative option a solid PN measurement methodology with a 65% cut-off size at 10 nm (SPN10).

2. This is an explanatory note accompanying the consolidated document addressing the changes to the current methodology and the proposed changes for the second alternative option to extend the particle size detection range to 10 nm particles.

II. Purpose and summary of the modifications

3. This proposed Amendment 6 to UN GTR No. 15 aims mainly at introducing as an alternative option a solid particle number measurement procedure with a cut-off size of approximately 10 nm (SPN10) differing in this from the existing procedure which has a 50% cut-off size at 23 nm (SPN23).

4. This amendment stems from the evidence that specific technologies like PFI and CNG engines may exhibit, in some cases, particle emissions close to the existing emission limit and at the same time a significantly high fraction of sub-23 nm particles. In view of a possible extension of the particle number limit to all combustion engines, the European Commission and other Contracting Parties had expressed the interest in a test procedure with a lower cut-off size in order to improve the control of particle emissions whatever the average size of the particles emitted. The IWG on PMP concluded that it would be extremely challenging to develop a reliable particle counting methodology with a d50 below 10 nm while a 65% cut-off size at 10 nm would be achievable by properly adapting the existing methodology.

5. For this reason the IWG on PMP has worked to identify the necessary changes which would allow an increase to the size range of the particles counted, whilst maintaining an appropriate level of repeatability/reproducibility, and at the same time trying to reduce as much as possible the impact on the testing burden and the measuring equipment required. The new proposed procedure has been assessed by means of an inter-laboratory exercise that has involved several laboratories located in Europe and Asia. This exercise has shown that the variability level of SPN10 results is at the same level as the SPN23 values.

6. Since a few Contracting Parties have asked to maintain the existing methodology with the 50% cut-off size at 23 nm in UN GTR No. 15, in agreement with the GRPE Secretariat, it is proposed to keep the existing methodology with some modifications and introduce the new procedure with the cut-off size at about 10 nm as an additional option. Both the changes to the existing methodology and the changes to extend the particle size detection range to 10 nm are summarized and explained in the table 1.

7. One of the more debated points in the IWG on PMP concerned the volatile particle remover and more specifically whether for SPN10 this should be based on a catalytic stripper or whether also the usual evaporation tube should be allowed. The results of the validation exercise have not provided clear evidence that one solution is definitely better than the other, but there is large consensus among the experts that the catalytic stripper minimizes the risk of artefacts due to too low dilution ratios. Moreover, losses are more critical for particles below 23 nm and if not properly measured and modelled, allowing both

systems could result in an increased variability among instruments based on different sample treatment approaches. For these reasons it has been decided to allow only the use of the catalytic stripper for SPN 10. However, in order to maintain the possibility of using sampling systems designed for SPN10 also for SPN23 measurement, the IWG proposes to modify also the existing procedure by removing the restriction that the sampling system parts shall not react with the exhaust gas components. In this way a sampling system with a catalytic stripper fitted with a condensation particle counter with the proper calibration can be used for the SPN23 measurement. As supported by several experimental data, the different losses between catalytic stripper and evaporation tube become important only below 23 nm and therefore, allowing the use of both devices for SPN23, should not result in an increased variability of the measurements.

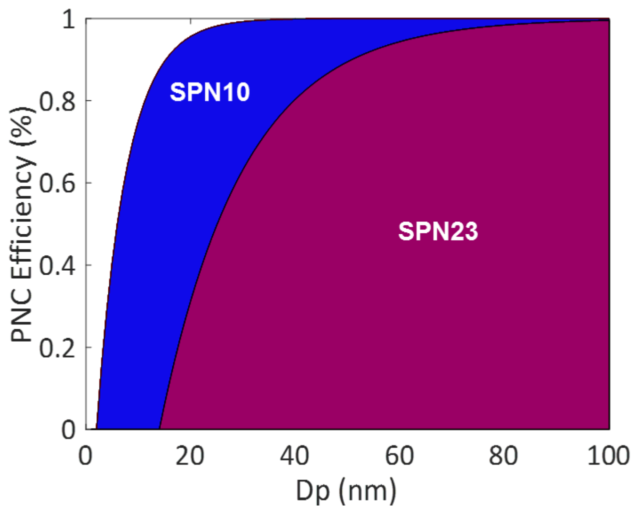
Table 1
Main changes to SPN23 and changes/additions for SPN10

Subject	*UN GTR 15, Annex 5 – Original requirements*	*Proposed changes for SPN23*	*Proposed changes for SPN10*	*Reasoning*
PNC efficiency	50±12 % @ 23 nm, >90% @ 41nm	None	65±15 % @ 10 nm, >90% @ 15nm	Typical PNC-efficiency, well tested in the field.
Maximum VPR-loss requirement	@ 30nm 30% and @ 50 nm 20% higher than @ 100 nm	None	Addition @15 nm 100 % higher than at 100 nm	No additional requirement below 15 nm since generation of particles < 15 nm challenging, uncertainties high
Polydisperse validation of VPR	a polydisperse 50 nm aerosol may be used for validation	None	Removed	Uncertainties @ 15 nm or below high → test serves no purpose
VPR validation	> 99.0 % vaporization of 30 nm tetracontane particles, with an inlet concentration of ≥ 10,000 per cm³ (Monodisperse)	None	> 99.9 % removal efficiency of tetracontane particles with count median diameter > 50 nm and mass > 1 mg/m3. (Polydisperse)	Secure the functioning of VPR also for PNC with 65±15 % @ 10 nm, >90% @ 15nm
Volatile Particle Remover (VPR)	All parts (of SPN-system) -- shall not react with exhaust gas components	-- VPR may be catalyzed (both heated evaporation tube and catalytic stripper allowed)	- the VPR shall be catalyzed (use of catalytic stripper only)	Minimize the risk of artefacts for SPN10. Comparability of PNC10 and PNC23 and possibility of using new sampling systems with CS also for SPN23 by fitting a PNC with a

Subject	*UN GTR 15, Annex 5 – Original requirements*	*Proposed changes for SPN23*	*Proposed changes for SPN10*	*Reasoning*
				D50 @ 23 nm.

8. A specific technical issue stemmed from the concern that to certify a vehicle for two different regions applying different PN limits (i.e. PN10 and PN23) either two different instruments or double testing might be required. This would lead in any case to increased testing costs and burden. Both those situations might be avoided if a test performed using the SPN 10 measurement procedure could also cover the SPN23 nm test.

9. In principle measuring SPN10 should result in higher PN values and therefore if the PN23 limit is met it can be concluded that the same limit would be more easily met when using the SPN23 procedure (see picture below). The IWG on PMP believes that this option is acceptable if any party would like to implement it.



10. As explained above, the proposed amendment does not just contain a second option for SPN10 measurement, but also includes a number of corrections/improvements to the existing and the proposed methodology. The following table describes in detail only the changes to the existing, SPN23 methodology. When in the "New text" column the marking "SPN23" does not appear, the changes also apply to the SPN10 procedure.

Annex 5	*Original text*	*New text*	*Justification*
4.3. PN measurement equipment (if applicable)	None	This regulation allows for two optional settings for the measurement of PN, differentiated by the particle electrical mobility diameter at which the PNC's detection efficiency is stated. The two values included are 23 nm and 10 nm. While most of the paragraphs and sub-paragraphs are common to the two different settings and have to be applied for both 23 nm and 10 nm PN measurement, some contain two different options starting respectively with the markings "SPN23" and "SPN10". Where such options exist, a Contracting Party wishing to	The text explains how to read the annex in the context of having common text, SPN10 specific text and SP23 specific text- as introduced by the new and the amended test procedure.

Annex 5	*Original text*	*New text*	*Justification*
		apply the 23 nm value should select the requirements starting with the marking "SPN23" whereas a Contracting Party wishing to apply the 10 nm value should select the requirements starting with the marking "SPN10".	
4.3.1.2.3.	All parts of the dilution system and the sampling system from the exhaust pipe up to the PNC, which are in contact with raw and diluted exhaust gas, shall be designed to minimize deposition of the particles. All parts shall be made of electrically conductive materials that do not react with exhaust gas components, and shall be electrically grounded to prevent electrostatic effects.	All parts of the dilution system and the sampling system from the exhaust pipe up to the PNC, which are in contact with raw and diluted exhaust gas, shall be made of electrically conductive materials, shall be electrically grounded to prevent electrostatic effects and designed to minimize deposition of the particles.	This change allows the use of a catalytic stripper in the sampling system used for SPN23 measurement
4.3.1.3.3.	The sample preconditioning unit shall: (a) Be capable of diluting the sample in one or more stages to achieve a particle number concentration below the upper threshold of the single particle count mode of the PNC and a gas temperature below 35 °C at the inlet to the PNC;	The sample preconditioning unit shall: (a) Be capable of diluting the sample in one or more stages to achieve a particle number concentration below the upper threshold of the single particle count mode of the PNC; (b) Have a gas temperature at the inlet to the PNC below the maximum allowed inlet temperature specified by the PNC manufacturer;	Permits the use of systems that can control the inlet temperature
4.3.1.3.3.	The sample preconditioning unit shall: (e) Be designed to achieve a solid particle penetration efficiency of at least 70 per cent for particles of 100 nm electrical mobility diameter;	The sample preconditioning unit shall: (f) Achieve a solid particle penetration efficiency of at least 70 per cent for particles of 100 nm electrical mobility diameter;	Only editorial change
4.3.1.3.3.	The sample preconditioning unit shall: (h) Also achieve more than 99.0 per cent vaporization of 30 nm tetracontane	The sample preconditioning unit shall: (h) SPN23: Achieve more than 99.0 per cent vaporization of 30 nm tetracontane	Only editorial change

Annex 5	*Original text*	*New text*	*Justification*
	(CH3(CH2)38CH3) particles, with an inlet concentration of ≥ 10,000 per cm³, by means of heating and reduction of partial pressures of the tetracontane.	(CH3(CH2)38CH3) particles, with an inlet concentration of ≥ 10,000 per cm³, by means of heating and reduction of partial pressures of the tetracontane.	
New 4.3.1.3.3.1	None	The solid particle penetration $P_r(d_i)$ at a particle size, d_i, shall be calculated using the following equation: $P_r(d_i) = DF \cdot N_{out}(d_i)/N_{in}(d_i)$ Where $N_{in}(d_i)$ is the upstream particle number concentration for particles of diameter d_i; $N_{out}(d_i)$ is the downstream particle number concentration for particles of diameter d_i; d_i is the particle electrical mobility diameter DF is the dilution factor between measurement positions of $N_{in}(d_i)$ and $N_{out}(d_i)$ determined either with trace gases, or flow measurements.	Definition of penetration. It was not defined
4.3.1.3.4.	The PNC shall: (d) Have a linear response to particle number concentrations over the full measurement range in single particle count mode;	The PNC shall: (d) Operate under single counting mode only and have a linear response to particle number concentrations within the instrument's specified measurement range;	Clarification of the already existing requirement of single counting mode
4.3.1.3.4.	The PNC shall: (g) Incorporate a coincidence correction function up to a maximum 10 per cent correction, and may make use of an internal calibration factor as determined in paragraph 5.7.1.3. of this annex but shall not make use of any other algorithm to correct for or define the counting efficiency;	The PNC shall: (g) Introduce a correction with an internal calibration factor as determined in paragraph 5.7.1.3.	The coincidence correction is outdated. New counters have more sophisticated algorithms
4.3.1.3.4.	None	The PNC shall:	Clarification that

Annex 5	*Original text*	*New text*	*Justification*
		(i) SPN23: The PNC calibration factor from the linearity calibration against a traceable reference shall be applied to determine PNC counting efficiency. The counting efficiency shall be reported including the calibration factor from the linearity calibration against a traceable reference.	the calibration factor has to be applied when checking the efficiencies at the cut-off curve sizes
4.3.1.3.4.	None	The PNC shall: (j) If the PNC applies some other working liquid besides n-butyl alcohol or isopropyl alcohol, the counting efficiency of the PNC shall be demonstrated with 4cSt polyalphaolefin and soot-like particles.	To confirm that PNC working fluid does not behave differently with soot particles, i.e. soot is somewhat hydrophobic and PNCs applying water as working fluid should be avoided
Table A5/2a PNC counting efficiency	23±1 41±1	23 41	Reference to “nominal” particle size
4.3.1.3.6.	Where not held at a known constant level at the point at which PNC flow rate is controlled, the pressure and/or temperature at the PNC inlet shall be measured for the purposes of correcting particle number concentration measurements to standard conditions	Where not held at a known constant level at the point at which PNC flow rate is controlled, the pressure and/or temperature at the PNC inlet shall be measured for the purposes of correcting particle number concentration measurements to standard conditions. The standard conditions are 101.325 kPa pressure and 0°C temperature.	Standard conditions defined to avoid ambiguity.
4.3.1.4.1.3.	The sampling probe or sampling point for the test gas flow shall be arranged within the dilution tunnel so that a representative sample gas flow is taken from a homogeneous diluent/exhaust mixture.	Becomes 4.3.1.4.1.4 and a new provision is inserted in 4.3.1.4.1.3	Change on indexing
New 4.3.1.4.1.3	None	SPN23: The evaporation tube, ET, may be catalytically active.	Clarification that catalytically active evaporation tube is permitted

Annex 5	*Original text*	*New text*	*Justification*
5.7.1.1.	The responsible authority shall ensure the existence of a calibration certificate for the PNC demonstrating compliance with a traceable standard within a 13-month period prior to the emissions test. Between calibrations either the counting efficiency of the PNC shall be monitored for deterioration or the PNC wick shall be routinely changed every 6. See Figures A5/16 and A5/17. PNC counting efficiency may be monitored against a reference PNC or against at least two other measurement PNCs. If the PNC reports particle number concentrations within ±10 per cent of the arithmetic average of the concentrations from the reference PNC, or a group of two or more PNCs, the PNC shall subsequently be considered stable, otherwise maintenance of the PNC is required. Where the PNC is monitored against two or more other measurement PNCs, it is permitted to use a reference vehicle running sequentially in different test cells	The responsible authority shall ensure the existence of a calibration certificate for the PNC demonstrating compliance with a traceable standard within a 13-month period prior to the emissions test. Between calibrations either the counting efficiency of the PNC shall be monitored for deterioration or the PNC wick shall be routinely changed every 6 months if recommended by the instrument manufacturer . See Figures A5/16 and A5/17. PNC counting efficiency may be monitored against a reference PNC or against at least two other measurement PNCs. If the PNC reports particle number concentrations within ±10 per cent of the arithmetic average of the concentrations from the reference PNC, or a group of two or more PNCs, the PNC shall subsequently be considered stable, otherwise maintenance of the PNC is required. Where the PNC is monitored against two or more other measurement PNCs, it is permitted to use a reference vehicle running sequentially in different test cells	This is obsolete for some instrument on the market as they have an integrated quality check option (e.g. pulse-height determination)
5.7.1.3	Calibration shall be traceable to a national or international standard calibration method by comparing the response of the PNC under calibration with that of:	Calibration shall be undertaken according to ISO 27891:2015 and traceable to a national or international standard by comparing the response of the PNC under calibration with that of:	Requirement that PNC calibration should follow the recently released ISO 27891:2015.
5.7.1.3	(b) A second PNC that has been directly calibrated by the method described above.	(b) SPN23: A second full flow PNC with counting efficiency above 90 per cent for 23 nm equivalent electrical mobility diameter particle s that has been	Requirement that facilitates the PNC calibration with a reference PNC different to that required in

Annex 5	*Original text*	*New text*	*Justification*
		calibrated by the method described above. The second PNC counting efficiency shall be taken into account in the calibration.	ISO 27891:2015.
5.7.1.3.1	For the requirements of paragraph 5.7.1.3.(a), calibration shall be undertaken using at least six standard concentrations spaced as uniformly as possible across the PNC's measurement range.	For the requirements of paragraphs 5.7.1.3.(a) and 5.7.1.3.(b), calibration shall be undertaken using at least six standard concentrations across the PNC's measurement range. These standard concentrations shall be as uniformly spaced as possible between the standard concentration of 2,000 particles per cm³ or below and the maximum of the PNC's range in single particle count mode.	Paragaphs 5.7.1.3.1 and 5.7.1.3.2 combined together and clarified
5.7.1.3.2	For the requirements of paragraph 5.7.1.3.(b), calibration shall be undertaken using at least six standard concentrations across the PNC's measurement range. At least 3 points shall be at concentrations below 1,000 per cm³, the remaining concentrations shall be linearly spaced between 1,000 per cm³ and the maximum of the PNC's range in single particle count mode.	Deleted	Paragaphs 5.7.1.3.1 and 5.7.1.3.2 combined together and clarified
Old 5.7.1.3.3 becomes new 5.7.1.3.2	For the requirements of paragraphs 5.7.1.3.(a) and 5.7.1.3.(b), the selected points shall include a nominal zero concentration point produced by attaching HEPA filters of at least Class H13 of EN 1822:2008, or equivalent performance, to the inlet of each instrument. With no calibration factor applied to the PNC under calibration, measured concentrations shall be within ±10 per cent of the standard concentration for each	For the requirements of paragraphs 5.7.1.3.(a) and 5.7.1.3.(b), the selected points shall include a nominal zero concentration point produced by attaching HEPA filters of at least Class H13 of EN 1822:2008, or equivalent performance, to the inlet of each instrument. The gradient from a linear least squares regression of the two data sets shall be calculated and recorded. A calibration factor equal to the reciprocal of the gradient shall be applied to the PNC under calibration. Linearity of response is calculated as the square of the Pearson product moment correlation coefficient (r) of the two data sets and shall be	Stricter requirement for the linearity (instead of +/-10%, reduced to +/-5%) from the slope. Additionally, linearity is no more compared on absolute, measured reference concentrations, but on forecasted reference concentration.

Annex 5	*Original text*	*New text*	*Justification*
	concentration, with the exception of the zero point, otherwise the PNC under calibration shall be rejected. The gradient from a linear least squares regression of the two data sets shall be calculated and recorded. A calibration factor equal to the reciprocal of the gradient shall be applied to the PNC under calibration. Linearity of response is calculated as the square of the Pearson product moment correlation coefficient (r) of the two data sets and shall be equal to or greater than 0.97. In calculating both the gradient and r2, the linear regression shall be forced through the origin (zero concentration on both instruments).	equal to or greater than 0.97. In calculating both the gradient and r2, the linear regression shall be forced through the origin (zero concentration on both instruments). The calibration factor shall be between 0.9 and 1.1 or otherwise the PNC shall be rejected. Each concentration measured with the PNC under calibration, shall be within ±5 per cent of the measured reference concentrations multiplied with the gradient, with the exception of the zero point, otherwise the PNC under calibration shall be rejected..	
5.7.2.1.	Calibration of the VPR's particle concentration reduction factors across its full range of dilution settings, at the instrument's fixed nominal operating temperatures, shall be required when the unit is new and following any major maintenance. The periodic validation requirement for the VPR's particle concentration reduction factor is limited to a check at a single setting, typical of that used for measurement on particulate filter-equipped vehicles. The responsible authority shall ensure the existence of a calibration or validation certificate for the VPR within a 6-month period prior to	Calibration of the VPR's particle concentration reduction factors across its full range of dilution settings, at the instrument's fixed nominal operating temperatures, shall be required when the unit is new and following any major maintenance. The periodic validation requirement for the VPR's particle concentration reduction factor is limited to a check at a single setting, typical of that used for measurement on particulate filter-equipped vehicles. The responsible authority shall ensure the existence of a calibration or validation certificate for the VPR within a 6-month period prior to the emissions test. If the VPR incorporates temperature monitoring alarms, a 13-month validation interval is permitted. It is recommended that the VPR is calibrated and validated as a complete unit. The VPR shall be	"Primary calibration" replaced "with latest complete calibration". Primary is ambiguous and unrealistic if interpreted as the first calibration of the instrument.

Annex 5	*Original text*	*New text*	*Justification*
	the emissions test. If the VPR incorporates temperature monitoring alarms, a 13-month validation interval is permitted. It is recommended that the VPR is calibrated and validated as a complete unit. The VPR shall be characterised for particle concentration reduction factor with solid particles of 30, 50 and 100 nm electrical mobility diameter. Particle concentration reduction factors f_r (d) for particles of 30 nm and 50 nm electrical mobility diameters shall be no more than 30 per cent and 20 per cent higher respectively, and no more than 5 per cent lower than that for particles of 100 nm electrical mobility diameter. For the purposes of validation, the arithmetic average of the particle concentration reduction factor shall be within ±10 per cent of the arithmetic average particle concentration reduction factor $\overline{f_r}$ determined during the primary calibration of the VPR.	characterised for particle concentration reduction factor with solid particles of 30, 50 and 100 nm electrical mobility diameter. Particle concentration reduction factors f_r (d) for particles of 30 nm and 50 nm electrical mobility diameters shall be no more than 30 per cent and 20 per cent higher respectively, and no more than 5 per cent lower than that for particles of 100 nm electrical mobility diameter. For the purposes of validation, the arithmetic average of the particle concentration reduction factor calculated for particles of 30 nm, 50 nm and 100 nm electrical mobility diameters shall be within ±10 per cent of the arithmetic average particle concentration reduction factor $\overline{f_r}$ determined during the latest complete primary calibration of the VPR.	
New 5.7.2.4	None	The instrument manufacturer must provide the maintenance or replacement interval that ensures that the removal efficiency of the VPR does not drop below the technical requirements. If such information is not provided, the volatile removal efficiency has to be checked yearly for each instrument.	Require the instrument manufacturer to recommend the maintenance interval to ensure proper functioning of the VPR
New 5.7.2.5	None	The instrument manufacturer shall prove the solid particle penetration $P_r(d_i)$ by testing one unit for each PN-system model. A PN-system model	Definition of penetration. It was not defined.

Annex 5	*Original text*	*New text*	*Justification*
		here covers all PN-systems with the same hardware, i.e. same geometry, conduit materials, flows and temperature profiles in the aerosol path. The solid particle penetration $P_r(d_i)$ at a particle size, d_i, shall be calculated using the following equation: $P_r(d_i) = DF \cdot N_{out}(d_i)/N_{in}(d_i)$ Where $N_{in}(d_i)$ is the upstream particle number concentration for particles of diameter d_i; $N_{out}(d_i)$ is the downstream particle number concentration for particles of diameter d_i; d_i is the particle electrical mobility diameter DF is the dilution factor between measurement positions of $N_{in}(d_i)$ and $N_{out}(d_i)$ determined either with trace gases, or flow measurements.	
5.7.3. PN measurement system check procedures	On a monthly basis, the flow into the PNC shall have a measured value within 5 per cent of the PNC nominal flow rate when checked with a calibrated flow meter.	On a monthly basis, the flow into the PNC shall have a measured value within 5 per cent of the PNC nominal flow rate when checked with a calibrated flow meter. Here the term ‘nominal flow rate’ refers to the flow rate stated in the most recent calibration for the PNC by the instrument manufacturer.	Clarification of what nominal flow rate means.
Annex 6			
2.11.1.2.2.	Each day, a zero check on the PNC, using a filter of appropriate performance at the PNC inlet, shall report a concentration of ≤ 0.2 particles per cm³. Upon removal of the filter, the PNC shall show an increase in measured concentration to at least 100 particles per cm³ when sampling ambient air and a return to ≤ 0.2 particles per cm³ on replacement of the	Each day, a zero check on the PNC, using a filter of appropriate performance at the PNC inlet, shall report a concentration of ≤ 0.2 particles per cm³. Upon removal of the filter, the PNC shall show an increase in measured concentration and a return to ≤ 0.2 particles per cm³ on replacement of the filter. The PNC shall not report any error.	The 100 particles/cm3 was removed because it was a random number that does not confirm the proper operation of the PNC and sometime too restrictive for low-ambient backgrounds

Annex 5	*Original text*	*New text*	*Justification*
	filter.		
Annex 7			
4. Determination of PN (if applicable)	C_b is either the dilution air or the dilution tunnel background particle number concentration, as permitted by the responsible authority, in particles per cubic centimetre, corrected for coincidence and to standard conditions (273.15 K (0 °C) and 101.325 kPa);	C_b is either the dilution air or the dilution tunnel background particle number concentration, as permitted by the responsible authority, in particles per cubic centimetre, corrected to standard conditions (273.15 K (0 °C) and 101.325 kPa);	Coincidence correction eliminated
	C_i is a discrete measurement of particle number concentration in the diluted gas exhaust from the PNC; particles per cm^3 and corrected for coincidence;	C_i is a discrete measurement of particle number concentration in the diluted gas exhaust from the PNC; particles per cm^3;	Coincidence correction eliminated

Appendix 2

Technical Report on the development of a new procedure at low temperature, during WLTP phase 2 and a new optional annex, WLTP Low Temperature Type 6 test in Amendment 6 to UN GTR No. 15 for the Worldwide harmonized Light vehicles Test Procedure (WLTP Low Temp)

I. Preface

1. The IWG on WLTP 16th session in The Hague Oct 2016 took place right after the conclusion of WLTP phase 1. It was then launched a new task force aiming to develop a new procedure at low temperature, during WLTP phase 2.[1] During that meeting, it was also decided that the Low and Realistic winter temperature Task Force (hereinafter LowT TF) should be chaired by the European Commission and open to all experts, stakeholders and CP representatives that have an interest in WLTP.

2. Soon after, it was described in the "Mandate and Terms of Reference" that "The purpose of the low temperature test is to check the level of specific pollutant emissions, CO_2, and range of vehicles in conditions that may easily be encountered during the winter season". 2020 [2]

3. Having asked the Contracting Parties (CPs) about the "the need to improve the current regulation" they expressed a number of needs that have been considered in the process of preparation of the informal document amending the working document for UN GTR No. 15 Amendment#6 which is presented here. Main concerns mentioned at the time were the effects on air quality, the environment, health, customer information and protection. Some of them are considered critical whereas others should be referred for information. According to the consultation to CPs, the UN GTR No. 15 should be used, as a basis for the work of this task force. The items which were specifically mentioned for discussion the low / realistic winter temperature, the cycle, the vehicle category to be included and parameters to be measured.

II. Background

4. Europe introduced in 1998 a type-approval test that allows to measure emissions at low temperatures from vehicles with positive-ignition engines. The Directive 98/69/EC of the European Parliament and of the Council[3] was a measure against air pollution by emissions from motor vehicles. This test was carried out on vehicles with petrol engines (M1 and N1 Class I) on a chassis dynamometer at -7 ±3 °C only over the Urban Driving Cycle (first part of the New European Driving Cycle, NEDC). The diluted exhaust gases should be analysed for CO and HC. Road-load can be either determined at -7 °C or adjusting the driving resistance for a 10% decrease of the coast-down time at 20°C. Regulation (EC) 715/2007[4] and its amendment EC 692/2008[5] brought some modifications,

[1] Reference Document WLTP-14-14e; ToR of the task force Low and Realistic Winter temperature; Meeting 9th January 2017 – Geneva. Consolidated version on the 25th of January 2017

[2] All documents mentioned in this summary can be found at CIRCA BC under: EUROPA > European Commission > CIRCABC > GROW > wltp> P > Low and realistic winter temperature TF, as well as in the UNECE Wiki page: https://wiki.unece.org/pages/viewpage.action?pageId=85295115

[3] Directive 98/69/EC of the European Parliament and of the Council of 13 October 1998, "Relating to measures to be taken against air pollution by emissions from motor 59 vehicles and amending Council Directive 70/220/EEC". Off. J. Eur. Un., L0069, pp1-65.

[4] 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 61 commercial vehicles (Euro 5

including the eligibility of vehicles with positive ignition engines (namely petrol hybrids, bi-fuel and flex-fuel), for the test, which is known as the Type 6 test from that moment. Most of the content found in this last regulation (EC 692/2008) regarding Type 6 test is identical to what is present in the 07 series of amendments to UN Regulation No. 83, where this test is referred to as Type VI[6].

5. Regulation EC 692/2008 includes the obligation of the manufacturers to present the type-approval authority with information showing that the NOx after- treatment device on diesel vehicles reaches a sufficiently high temperature for efficient operation within 400 seconds after a cold start at -7 °C and strategy of EGR systems used in diesel vehicles at low temperature. Similar procedures to the Type 6 test are applied in the USA (CFR 1066 Subpart H) where the test is also performed at -7 °C (±1.7 °C) and the determination of the road-load is done in the same way determined at -7 °C or adjusting the driving resistance for a 10% decrease of the coast- down time), there are important differences as well. In the USA, the entire FTP testing procedure is used, while only the UDC is used in EU. The CFR 1066 procedure foresees the use of the vehicle's heater and defroster during the test, while the Type 6 test specifies that these auxiliaries should not be used[7]. Moreover, in the USA otto-cycle and diesel vehicles must be tested at low temperature.

III. Introduction

6. After the establishment in the Global Registry as UN GTR No. 15 in March 2014, ECE/TRANS/WP.29/AC.3/39 on the authorization to further develop the work on Phase 1b was adopted to solve the remaining issues of WLTP Phase 1a. WLTP Phase 1b activities were completed and amendments to UN GTR No. 15 were submitted in October 2015 to be considered at the GRPE January 2016 session.

7. An extension of the mandate for the WLTP IWG, sponsored by the European Union and Japan was granted to tackle the development of the remaining issues. Phase 2 activities started immediately after the endorsement of this authorization by WP.29 and AC.3 at their November 2015 sessions.

8. The scope of work in Phase 2 covered, among other issues, the effect of Low ambient temperature on emissions and range.

9. With this premises and since January 2017, the LowT TF has been working regularly on a new Type 6 test to replace the Type VI test in UN Regulation No. 83. The work has been supported by a group of approximately 25 persons, including representatives from CP and stakeholders, which have been actively and regularly participating in the meetings and web-conferences. Along these years, the TF has hold forty three encounters, either face-to-face meetings (usually twice per year) or via telco/ web conference. During the last year, the TF hold nineteen encounters, including a face-to-face meeting during the 28th IWG on WLTP meeting in Bern in September and the intermediate IWG on WLTP meeting in February 2020. The work was also complemented by intense collaboration with Sub-Group (SG) EV, where from fall 2019 until mid-2020 alone, about twenty-two encounters, including web conference, face-to-face and drafting meetings were hold and specifications for the low temperature test procedure for electrified vehicles, amongst others, were developed.

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and Euro 6) and on access to vehicle repair and maintenance information. Off. J. Eur. Communities L171/1; 2007.

[5] 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. Off. J. Eur. Communities L199/1; 2008.

[6] https://www.unece.org/fileadmin/DAM/trans/doc/2018/wp29grpe/GRPE-76-24e.pdf

[7] US. EPA; http://www.ecfr.gov/cgi-bin/text-idx?SID=ba447754d6f766672ab21e5aa4146283&mc=true&node=pt40.33.1066&rgn=div5#sp40.37.1066.h

10. Early discussions in the preparation of the Terms of Reference (ToR) resolved that, as far as conventional vehicles are concerned, the test procedure was meant to assess the impact of low temperature on the efficiency of after-treatment devices or other emission control technologies.

11. In order to properly reflect the conditions that are encountered in real world winter conditions, the road load should be representative of the increased resistance to progress at low temperatures due to the higher air density and other factors (viscosity of transmission lubricant,…). A proper procedure to define the road load and consequently the dyno settings was developed.

12. Another element to be addressed was whether the emissions should be predominantly measured during the cold start and immediately after or during the whole WLTC cycle.

13. Moreover, low temperatures largely affect the range of electrified vehicles as a consequence of a reduced efficiency of the battery, and also due to the additional energy consumption from auxiliaries (i.e. heating system). This aspect does not fall within the typical scope of the low temperature tests, especially due to the absence of exhaust emissions in the case of battery electric vehicles. However, this is an important element of the so-called ‘range anxiety’ which exists among potential EV consumers.

14. The mandate of the Low and realistic winter temperature TF

15. According to the ToR[8], The low and realistic winter temperature Task Force was preordained to:

(a) Be open to all experts, stakeholders and CP representatives that have an interest in WLTP;

(b) Be chaired by the European Commission;

(c) Develop a harmonised low and realistic winter temperature test procedure (Type 6 test) for the assessment of the emissions (including CO_2), vehicle fuel consumption and electric range, at low and/or realistic winter temperature

(d) Propose a harmonised procedure to assess the impact of low temperatures on the range of electric vehicles for proper information of the consumers;

(e) Act as a platform for the exchange of information and contributions of stakeholders, to be discussed and agreed during the development process;

(f) Report to the IWG on WLTP on the progress;

(g) Deliver technical advice and make recommendations to the IWG on WLTP on the document strategy, i.e. a new UN GTR or an annex to UN GTR No. 15. Provide a draft text and contribute to the drafting process.

(h) Focus only on the technical issues regarding the procedure to be developed, while decisions are made at the IWG on WLTP level

(i) Develop a proposal for the handling of families for low temperature requirements

(j) Promote interaction and exchange of information with other IWG Groups, sub-group and task forces, in particular with WLTP Sub-Group-EV and IWG on PMP.

16. The Task Force worked intensively to define the temperature for the procedure in order to be representative of low and/or realistic winter temperatures.

(a) Define the driving cycle to be used for the procedure at low and/or realistic winter temperature and more specifically whether the whole WLTC cycle should be used or a reduced part of it.

[8] Reference Document WLTP-14-14e -; ToR of the task force Low and Realistic Winter temperature; Meeting 9th January 2017 – Geneva. Consolidated version on the 25th of January 2017

(b) Define the procedure for the adjustment of the road load and consequently of the dyno settings.

17. The work needed specific studies or requests from the experts in the task force, specifically regarding a/ the procedure for assessing the pollutant emissions in conventional and electrified vehicles (LowTemp-Emissions); b/ the procedure for assessing the impact of the low temperature test on the range of electrified vehicles (LowTemp-Range):

IV. LowTemp-Emissions

18. The scope was to develop a procedure to check specific emissions including CO_2. The specific objectives were the following:

(a) Define the procedure to measure the distance specific emissions of the following compounds: total HC, CH_4 and NMHC, CO, NOx, CO2 as well as PM and Particle Number, paying attention to the measurement procedures for those compounds not currently regulated at low temperatures.

(b) Define specific provisions for the low temperature procedure for diesel and hybrid vehicles where necessary.

V. LowTemp-Range

19. The scope was set to develop a procedure to determine the impact on the range of electrified vehicles at low temperature. The specific objectives were the following:

(a) Assess whether the shortened procedure for PEV and OVC-HEV range measurement was appropriate at low temperatures or otherwise agree on a new procedure for range determination

(b) Develop a procedure to assess the impact of auxiliary systems (e.g. thermal comfort systems,…) on the energy consumption and the range of electrified vehicles

20. To reach the scope of the task force which can be adapted to the specific purpose of each deliverable.

(a) Start with an analysis of the existing normative and literature on the method;

(b) Prepare a comparative analysis amongst the different regional procedures;

(c) Propose a way forward for the development of a harmonized procedure, including considerations on whether there is need for experimental activities and to what extent;

(d) Develop the harmonized method;

(e) Validate the method

21. Under proposal of the LowT TF, to the IWG on WLTP, it was agreed to produce an optional annex to UN GTR No. 15.[9] Concerning the title of the UN GTR optional annex, it was agreed to name it “WLTP Low Temp”[10]. The members of the Low T TF also agreed that the name of the test should be "Type 6" [11]

22. The scope of the text and the application should be the same as the UN GTR No. 15; it should be applicable to all vehicle although it was agreed to exempt FCHV for the first version of the optional annex.[12]

23. Key changes to the UN Regulation No. 83 Type VI test include:

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[9] See comments in sheet 2019-05-16 & 2019-09-09: https://wiki.unece.org/pages/viewpage.action?pageId=85295115

[10] https://wiki.unece.org/pages/viewpage.action?pageId=85295115 (See comment in 2019-09-09)

[11] https://wiki.unece.org/pages/viewpage.action?pageId=85295115 (See comments in 2019-04-17)

[12] https://wiki.unece.org/pages/viewpage.action?pageId=85295115 (See comments in 2019-09-09)

(a) Drafting an optional annex to UN GTR No. 15 for low and realistic winter temperature

(b) Applicable to all type of vehicles and fuels (exempt FCHV for the first version of the optional annex)

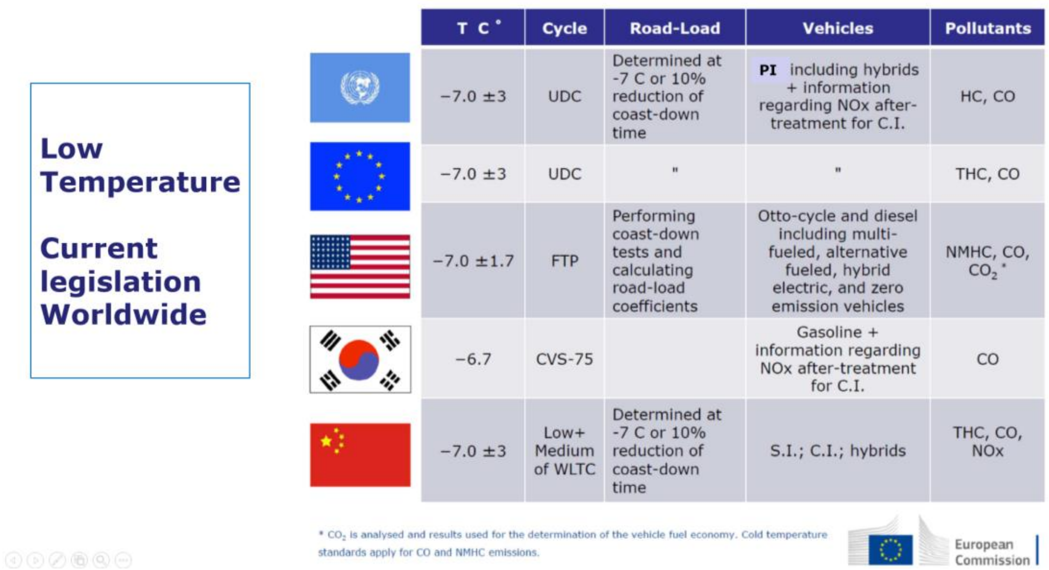
(c) Purpose is to check compliance of pollutant emissions (THC, CH4, NMHC, CO, NOx, PM, PN) and provide information for CO2, FC, EC and range.

24. Considerations on family concept and the possibility of including simulation methods were the centre of intense and prolific discussions and were to be included in the optional annex. Nevertheless, a simulation method is currently not included.

25. During the definition of the scope of the Type 6 test, Contracting Parties indicated that the focus of this test was on criteria emissions for vehicles using internal combustion engines and energy consumption and range from electrified vehicles. Hence, for vehicles equipped with internal combustion engines the family was defined using the same criteria implemented in the PEMS family of the European and Global RDE. A series of adjustments were included to assure that the vehicle selected for the Type 6 test was previously tested over the Type 1 procedure. For pure electric vehicles new provisions that cover the main elements related to the impact of the temperature on energy consumption and range were defined.

VI. Analysis of the existing normative

26. To reach the scope of the task force, there was an initial analysis of the existing normative and literature on the method and it was prepared a comparative analysis among the different regional procedures (See figure below).



Low Temperature

Current legislation Worldwide

	T C°	Cycle	Road-Load	Vehicles	Pollutants
	−7.0 ±3	UDC	Determined at -7 C or 10% reduction of coast-down time	**PI** including hybrids + information regarding NOx after-treatment for C.I.	HC, CO
	−7.0 ±3	UDC	"	"	THC, CO
	−7.0 ±1.7	FTP	Performing coast-down tests and calculating road-load coefficients	Otto-cycle and diesel including multi-fueled, alternative fueled, hybrid electric, and zero emission vehicles	NMHC, CO, CO_2 *
	−6.7	CVS-75		Gasoline + information regarding NOx after-treatment for C.I.	CO
	−7.0 ±3	Low+ Medium of WLTC	Determined at -7 C or 10% reduction of coast-down time	S.I.; C.I.; hybrids	THC, CO, NOx

* CO_2 is analysed and results used for the determination of the vehicle fuel economy. Cold temperature standards apply for CO and NMHC emissions.

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27. The work in the LowT TF needed also some specific studies from the experts in the group, specifically regarding the procedure for assessing the pollutant emissions in conventional and electrified vehicles as well as the procedure for assessing the impact of the low temperature test on the range of electrified vehicles. Experts in the LowT TF have also worked in the assessment of the impact of auxiliary systems (e.g. thermal comfort systems) on the energy consumption and the range of electrified vehicles. Besides, the TF has been working in the development of a proposal for the handling of families for low temperature requirements. Therefore, the TF has been acting as a platform for the exchange of information and contributions of stakeholders to be discussed and agreed during the development process.

28. Moreover, from the Chair of the TF, there has been an intense work of promotion of interaction and exchange of information with other IWG Groups, sub-groups and task forces, in particular with WLTP Sub-Group EV. The Chair has also been reporting

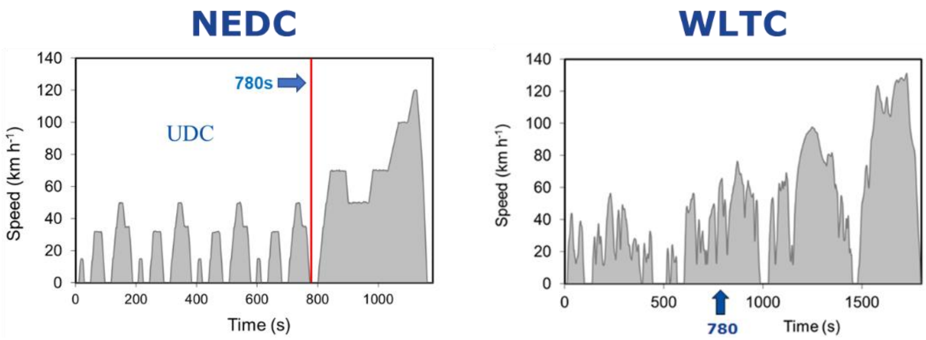
regularly to the IWG on WLTP on the progress and decisions. On this respect, the TF has focused only on the technical issues regarding the procedure to be developed and delivered technical advice and made recommendations to the IWG on WLTP on the document strategy (an optional annex to UN GTR No. 15) while decisions were made at the IWG on WLTP level. Finally, the Task Force was deeply committed to provide a draft text and contributed to the drafting process.

VII. The Outcome: an "optional annex" for a new Type 6 test.

29. The outcome of the work of the LowT TF is a document, which provides test procedures to test conventional and electrified vehicles at cold ambient temperatures to be added as a new optional Low Temperature (Type 6) test to UN GTR No. 15. [13]

30. During the work and drafting of that document, the LowT TF has confirmed the set point temperature for the procedure (-7°C) and the requirements that the new procedure of the Type 6 test would have in a new optional annex. The procedure follows UN GTR No. 15 and the Type 1 test, therefore, the new test is performed following the WLTC, replacing the NEDC (shorter and less realistic).

Figure 1
Left panel: old test cycle for type approval in (NEDC) – Right panel: new test cycle (WLTC) for type approval



31. The optional annex was presented as "a working document" for its consideration, and previously to the delivery of the Working Document, due in March 2020, 20th (200110 - Low Temp Annex based on ECE-TRANS-WP29-2019-62e.docx [14])

32. The approach has been to leave the Type 1 test paragraphs of Annexes 1- 8 unaltered and to indicate in the optional annex where the Type 6 test would alter those requirements. However, there were some Type 6 related elements, which were expected to be incorporated into the current UN GTR No.15 sections. These included a definition of a Low Temperature Family in Section 5 of the UN GTR and specifications for Type 6 reference fuels in Annex 3.

33. The WLTP Low Temperature Type 6 test optional Annex 13 describes the procedure for undertaking the Type 6 test defined in paragraph 6.2.4. of Amendment 6 to UN GTR No. 15. At the option of the Contracting Party this annex may be omitted. Fuel cell hybrid vehicles are currently exempted from the Type 6 test.

34. Type 6 test requirements state that the Type 6 should be undertaken according to the definitions, requirements and tests set out in paragraphs 3 to 7 of UN GTR No. 15. Application and amendments to the requirements of Annexes 1 to 8 inclusive of UN GTR No. 15 are now specified in paragraphs 2.1. to 2.7. of the optional annex 13.

[13] The document is based on the text of UN GTR No. 15 Amendment #5 as submitted for vote at the June 2019 session of WP.29.

[14] On the 6 January 2020, Standard text of UN GTR No. 15 was deleted to just leave the Type 6 test relevant sections. Document uploaded in: https://wiki.unece.org/display/trans/Optional+annex+Low+T+-+Drafting

35. Other premises in UN GTR No. 15 were identified to apply to the optional annex too, namely:

36. Worldwide light-duty test cycles (WLTC): The requirements of Annex 1 also apply for the purposes of the optional annex.

37. Gear selection and shift point determination for vehicles equipped with manual transmissions: The shifting procedures described in Annex 2 also apply with the following specific provision for Type 6 testing: It is allowed to set nmin_drive and ASM values which are different than those used for Type 1 testing.

38. Reference Fuels: The reference fuels to be used for the Type 6 test are those specified in Part II of Annex 3, or Part I if a reference fuel is not provided in Part II (e.g., reference diesel). At the option of the manufacturer and approval of the responsible authority a reference fuel as specified in Part I of Annex 3 may be used.

39. Road load and dynamometer setting: For the vehicle to be tested, the chassis dynamometer load setting determined according to paragraph 8.1.4. or paragraph 8.2.3.3. of Annex 4 is to be applied.

40. The original idea was to take a similar approach as in UN Regulation No. 83, to either determine the road load at a temperature of -7 °C or increase the road load by 10%. In both cases, the road load would be applied as a target chassis dynamometer setting for the Type 6 test. During the discussions it was recognized that the method already included in the European Euro 6 legislation for the determination of the ATCT correction might also prove useful for the Type 6 test, refer to Regulation (EC) 2017/1151 and 2018/1832. In this approach the same chassis dynamometer setting is applied as for the Type 1 test, except for a correction to the f_2 road-load coefficient which is corrected upwards to compensate for the increased air density at the lower temperature. In the case of the low temperature test, that compensation on f_2 is 10%. Even though the same f_0 road-load coefficient is used for the chassis dynamometer setting, the vehicle will experience a higher rolling resistance because of the lower tyre temperature during the test. The advantage of this method is that the chassis dynamometer setting procedure in the low temperature test cell can be eliminated. However, this is only allowed if the manufacturer has demonstrated equivalency between the chassis dynamometers of the Type 1 and the Type 6 test, and if the parasitic losses have been taken into account.

Table A2/1

Main topics of the optional annex

Nº	*Discussion point*	*Conclusion*
1	Test temperature	-7ºC
2	Number of phases of the WLTC	EU 4 phases, Japan 3 phases.
3	Reference fuels	Specific provisions for gasoline, LPG and ethanol were added. In order to satisfy the specific requirements of bi-fuels testing and the switch from petrol to gas and the maximum allowed energy consumed by operation on petrol, it was indicated by OICA, and supported by Japan and EC to include these two elements using data provided after validation of the type 6 procedure, and including this point in the technical report.
4	Family definition	Based on PEMS family and Type 1 test. Focussed on pollutant emissions and electric range.
5	Use of auxiliary devices	Currently introduce the use of thermal comfort systems, Passing-beam (dipped-beam) headlamps and electrical system(s) to defrost. Other systems such as radiant panels and heating seats will be addressed at a second stage.

Nº	*Discussion point*	*Conclusion*
		The work was divided in three steps: 1.Assessment of auxiliaries to be included (Heating system for cabin, De-frosting/icing/fogging system, Thermal storage system, Battery Thermal Management system, Additional burners, Lighting, Infotainment equipment) 2. Identify conditions to apply to a selected auxiliary in Assessment Matrix (preconditioning, soak, test) 3. Procedure description for selected auxiliaries Initial orientations from Low Temp TF about the Test Procedure to include auxiliaries previewed: A. Auxiliary devices Test Procedure had to be as simple as possible to avoid test burden; B. Auxiliary devices should use the same procedure for different powertrains when/if possible; C. USA's procedure for auxiliary devices could be used as bases.
6	Equipment	Make sure to avoid water condensation.
7	Soak	1. A soak period prior to preconditioning was included. It was agreed to indicate that the soak before preconditioning may be omitted if the manufacturer can justify to the approval of the responsible authority that this soak will have negligible effects on the criteria emissions. 2. A 12-36h soak period prior to test was agreed.
	Soak before pre-conditioning	At the request of the manufacturer, and with the approval of the responsible authority, the soak before preconditioning may be omitted if the manufacturer can justify that this soak will have negligible effects on the criteria emissions. As an example, the effects on the criteria emissions may be non-negligible in the case that the vehicle has an aftertreatment system that uses a reagent. Japan supports new EC proposal as long as this option shall not be applied for PEV and CD test of OVC-HEV.
8	Road-load	Follow the approach of the Ambient Temperature Correction Test as used in the Euro 6 legislation.
9	Preconditioning	At -7ºC.
10	Procedure for OVC-HEV	CD and CS testing was requested for OVC-HEV.
11	Calculation	Do not apply humidity correction.
12	Criteria for number of tests	Based on criteria emissions for vehicles with ICE, and on declared electric energy consumption and PER for PEVs.
13	HV battery charge	Starting within 1 hour after preconditioning.
14	Possible test sequence options for OVC-HEV	1. CD / 2. CS / 3. CD + CS / 4. CS + CD / 5. CS + CS / 6. CD + CD

Nº	*Discussion point*	*Conclusion*
	testing	
15	Cycle for PEV	The PEV Type 6 test procedure consists of one dynamic segment (DS), followed by one constant speed segment (CSS), whereas the DS consists of (3) applicable WLTP test cycles (WLTC) in accordance with paragraph 1.4.2.1. of Annex 8 (Type 1).

41. During the development of a test procedure for PEV, applying the approach from Type 1 adapted for Type 6 conditions consecutive cycle test procedure/shorten test procedure (CCP/STP) was considered the best solution given the time constraints at this stage. The idea of a shortened or alternative STP was considered to be too premature for the implementation into a first working document. Furthermore, a shortened/alternative STP was recognized to have promising aspects to be discussed at a later stage, ideally for both, Type 1 and Type 6, in order to have the same procedure to be performed at both conditions.

42. Later in the development process and after scrutiny of test data by several stakeholders raising possible concerns with the original approach (see e.g. document WLTP-ITM-03e), guidance from WLTP IWG in the meeting on 20 February 2020 for SG EV was to focus on the development of an “alternative/shortened STP” (i.e. a specific PEV Type 6 test procedure).

43. Therefore, the PEV Type 6 test procedure was developed accordingly and now consists of one dynamic segment (DS), followed by one constant speed segment (CSS), whereas the DS consists of (3) applicable WLTP test cycles (WLTC) in accordance with paragraph 1.4.2.1. of Annex 8 (Type 1) of GTR No. 15.

VIII. Traceability of the informal document and decision-making process

44. The informal document for an optional annex on low temperature has been built-up following a dedicated file containing all open-closed issues discussed in the TF. The evolution and construction of the informal document for the new technical annex to the Type 6 test can be followed by considering the excel file where all changes have been registered and appear with the date of the modification/agreement.

IX. WLTP_Low_Temp_TF_Status_list_v2020-xx-xx.xlsx-[15] [16]

https://wiki.unece.org/display/trans/Optional+annex+Low+T+-+Drafting

45. All main changes done in the text during the drafting of the informal document were indicated with margin notes and the latest are dated on the week previous to the delivery of the Informal document to the secretariat of the GRPE in January 2020. Comments were provided at the relevant points of Annexes 1-8 which have been identified as being areas of UN GTR No. 15 which may need to be amended via the Optional Annex.

[15] This serial number was continued and updated by the chair of the TF. In order to track the evolution of the discussions and decisions inside the LowT TF, all excel files detailing the **Low T TF status list** were saved and made available in CIRCAC-BC and in UNECE Wiki page dedicated the LowT TF (https://wiki.unece.org/pages/viewpage.action?pageId=85295115)

[16] This document was periodically updated by the drafting coordinator or by any of the Chairs for the LowT TF or the SG EV and always following the discussions in the lowT TF, the SG EV and corresponding drafting sub-groups. In order to track the evolution of the discussions and decisions, the files detailing the **progress in the drafting of the optional annex for lowT** were saved in a dedicated folder in UNECE Wiki page Low TF domain, created *ad-hoc* for this drafting process: https://wiki.unece.org/display/trans/Optional+annex+Low+T+-+Drafting

46. The informal document of the Low Temp optional annex was presented as a Working Document by the WLTP IWG to the Secretariat of the GRPE on the 20th of March 2020. From that moment, the work in the Task Force continued to solve the remaining issues in open square brackets and the document updated regularly was named:

X. 200xyy_Status Square bracket topics_Amd_6 WD

47. The new files following the discussions could be found in the same wiki page, https://wiki.unece.org/display/trans/Optional+annex+Low+T+-+Drafting

48. Final sessions (Tele conference) for the drafting of the optional annex took place on the 2nd and 3rd of June and the new and latest version of the

"200528_Status Square bracket topics_Amd_6 WD_20200604_V4" was loaded in the folder

49. LowT TF final drafting sessions (Telco)

50. The very final version of the WLTP Low Temperature Type 6 test (optional annex) was uploaded to the UN Wiki for latest version of Amendment 6 to UN GTR No. 15 text, along with the documents Sub-Annex 1 (Pure electric and hybrid electric vehicles) to Annex 13, the Appendix 1 (REESS state of charge profile) and the Appendix 2 (Vehicle preparation, preconditioning and soaking procedure for Type 6 testing of OVC-HEVs, NOVC-HEVs and PEVs)

51. Further improvements in Annex 13 of the UN GTR No. 15; In the development process of the WLTP Low Temperature Type 6 test (optional annex 13), several critical decisions had to be taken in order to deliver the final text of the test procedure to be integrated into Amendment 6 to UN GTR No. 15 on time. It also appeared to the experts involved, that there is room for improvement of the current text. Therefore, a possible update of the WLTP Low Temperature Type 6 test procedure for pure ICE and electrified vehicles based on a validation exercise could further improve Annex 13, as well as Annex 13 Sub-Annex 1 of Amendment 6 to UN GTR No. 15.

Appendix 3

Conformity of Production for Type 1 test and OBD

I. Context

1. This technical report on the CoP provides a brief overview of the test procedure and the evaluation methods for OBD and Type 1 testing for CoP. The complete CoP procedure with all the details can be found in Annex 14. For this Technical Report the main focus is laid on the parts of the procedure that were added as new elements to the CoP procedures already in place in existing UN Regulations and regional legislation.

2. The CoP Taskforce took as a basis the existing CoP procedures in UN Regulations Nos. 83, 101, the European CoP procedure specified in Regulation (EU) 2017/1151 and the procedure which was under development at the time in Japan by the MLIT and JAMA. Where considered appropriate and necessary, these procedures were amended and improved in trying to achieve a harmonised approach for UN GTR No. 15.

3. During the process of developing the CoP test procedure by the CoP Taskforce, it proved difficult to satisfy the needs of the different Contracting Parties (CPs). It was impossible to reach consensus on a fully harmonised approach. With that conclusion in mind, the focus of the taskforce shifted towards establishing at least a harmonised test procedure for CoP, and allow the evaluation of the CoP test as a CP option. This approach enables to perform one and the same CoP test, but an evaluation according to the different needs of the CPs, thereby reducing the testing burden for manufacturers producing vehicles for different regions.

II. CoP test for OBD

4. The CoP test procedure on OBD is largely based on the text in UN Regulation No. 83. A CoP test is triggered when the responsible authority finds that the quality of production is unsatisfactory. The CoP test itself is a repetition of the OBD test procedure as described in Appendix 1 to Annex 11, without any further amendments. If the tested vehicle does not fulfil the requirements, another vehicle is added to the sample, up to a maximum of 4 vehicles. At least 3 vehicles shall meet the requirements described in Appendix 1 to Annex 11. The OBD family for CoP is the same as the CoP family for Type 1 CoP tests.

III. CoP test for Type 1 test

5. The applicable Type-1 CoP requirements for the different types of vehicles are listed in Table A14/1. It was decided that NOVC-FCHV and OVC-FCHV are currently exempted from CoP testing.

6. A CoP family is essentially the same as the interpolation family. Since the CoP is connected to the vehicle production, it was chosen to split the CoP family for different production facilities. As a consequence, one interpolation family can be present in different CoP families. Under the conditions specified in paragraph 1.3. and 1.3.1.2 of Annex 14, CoP families can be merged. The manufacturer also has the option to create smaller CoP families.

7. The test frequency is set at a minimum of one verification for each CoP family per 12 months. The manufacturer shall specify the planned production for each CoP family, and inform the responsible authority in case there are significant changes. For a planned production exceeding 7,500 vehicles per 12 months, at least one verification per 5,000 vehicles needs to take place (rounded to the nearest integer). As a CP option, the frequency is increased to one verification per 3 months for productions exceeding 17,500 vehicles per

12 months, respectively one verification per month for productions exceeding 5,000 vehicles per month.

8. For a CoP verification, the Type 1 test is carried out on a minimum of three randomly selected vehicles from the production, selected across the interpolation families in the CoP family and/or different production facilities, if applicable. The verification process is shown in the Flowchart of Figure A14/1. The outcome is a 'pass' or a 'fail' decision. However, if a decision was not reached another test vehicle is added to the sample up to a maximum of 16 vehicles or, as an alternative CP option, a maximum of 32 vehicles for criteria emissions and 11 for fuel efficiency and electric energy consumption.

9. The fuel used during the CoP test is at the option of the CP, either a reference fuel in accordance with Annex 3, or a commercial fuel, with an alternative manufacturer option to use a reference fuel in accordance with Annex 3.

10. For the evaluation of the CoP for PEVs and for OVC-HEVs in charge-depleting mode an alternative CoP evaluation procedure was developed. The electric energy consumption (EC) is only measured during the first applicable WLTP test cycle. This EC value is then evaluated against the charge-depleting EC of the first cycle at type-approval, corrected by an adjustment factor to observe the difference between the declared and measured EC. In this way, the significant test burden for the manufacturer for CoP testing can be reduced considerably, while it is still an effective method to check the CoP on EC. The determination of the EC values for CoP evaluation is described in Appendix 8 to Annex 8.

11. Vehicles which are tested for CoP are relatively new, while a type approval vehicle has already been run in. This may potentially have an effect on the CO_2 emissions/fuel efficiency and criteria emissions. To take the difference of emission performance into account, run-in factors may be derived for the CoP verification. Depending on the CP they are applied for:

(a) Criteria emissions, CO_2 emissions and/or electric energy consumption

(b) Fuel efficiency (FE) and/or electric energy consumption

12. During the development of the run-in test procedure, the existing procedures were considered inadequate, particularly on the fact that they assume a linear evolution of the CO_2 emissions and fuel efficiency, and the actual odometer setting of the tested vehicles is not taken into consideration.

13. The newly developed run-in procedure fits the measured CO_2 emissions respectively FE and the corresponding odometer settings of the tested run-in vehicles to a natural logarithmic curve by a least square regression analysis and, as a CP option, corrects this downwards by the standard deviation of the difference between the measured and fitted CO_2 emissions. The run-in factor to be applied to the tested CoP vehicle will then be determined as a function of its actual odometer setting.

14. At the option of the CP the run-in factors may also be applied for criteria pollutants. In this case, the results are plotted on a linear regression line as a function of the actual odometer setting.

15. Another new element is that the mileage accumulation on the run-in vehicles may not exceed that of the type-approval vehicle to avoid any overcorrection.

16. As an alternative to the measured run-in factors, a default run-in factor may be applied of 0.98 for the CO_2 emissions respectively 1.02 for the fuel efficiency, depending on the CP option. There are no default run-in factors for criteria emissions and electric energy consumption.

17. Two separate evaluation procedures have been developed in parallel, both are included as a CP option. One is for the CoP evaluation of CO_2 emissions, electric energy consumption and criteria emissions, and the other for the CoP evaluation of fuel efficiency electric energy consumption and criteria emissions.

18. Evaluation of criteria emissions depends on the CP option, but in general the procedure is largely the same as in UN Regulation No. 83, respectively the CoP evaluation

procedure in (EU) 2017/1151. In both cases an evaluation criterion is derived on the measured values of the sample, the limit value of the criteria emission component, the sample size and the variance in the measured results. The outcome of the evaluation can result in a ‘pass’, ‘fail’ or ‘test another vehicle’.

19. For the evaluation of CO_2 respectively Fuel Efficiency, the contracting parties have developed their own individual evaluation procedures. The details can be found in Appendix 2 to Annex 14.