Only the original UN/ECE texts have legal effect under international public law. The status and date of entry into force of this Regulation should be checked in the latest version of the UN/ECE status document TRANS/WP.29/343, available at: https://unece.org/status-1958-agreement-and-annexed-regulations

UN Regulation No 117 – Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and/or to adhesion on wet surfaces and/or to rolling resistance [2025/1453]

Incorporating all valid text up to:

Supplement 2 to the 04 series of amendments – Date of entry into force: 10 January 2025

This document is meant purely as documentation tool. The authentic and legally binding texts are:

ECE/TRANS/WP.29/2013/59
ECE/TRANS/WP.29/2014/4
ECE/TRANS/WP.29/2014/6
ECE/TRANS/WP.29/2013/66 (as amended by paragraph 56 of the report ECE/TRANS/WP.29/1108)
ECE/TRANS/WP.29/2015/5
ECE/TRANS/WP.29/2015/65 (as amended by paragraph 66 of the report ECE/TRANS/WP.29/1116)
ECE/TRANS/WP.29/2016/60
ECE/TRANS/WP.29/2019/54
ECE/TRANS/WP.29/2020/6 (as amended by paragraph 85 of the report ECE/TRANS/WP.29/1151)
ECE/TRANS/WP.29/2020/75
ECE/TRANS/WP.29/2021/8 (as amended by paragraph 78 of the report ECE/TRANS/WP.29/1157)
ECE/TRANS/WP.29/2022/8
ECE/TRANS/WP.29/2022/83
ECE/TRANS/WP.29/2023/6 (as amended by paragraph 88 of the report ECE/TRANS/WP.29/1171)
ECE/TRANS/WP.29/2023/8
ECE/TRANS/WP.29/2023/76
ECE/TRANS/WP.29/2024/65

Contents

Regulation

1. Scope
2. Definitions
3. Application for approval
4. Markings
5. Approval
6. Requirements
7. Modifications of the type of tyre and extension of approval
8. Conformity of production
9. Penalties for non-conformity of production
10. Production definitively discontinued
11. Names and addresses of Technical Services responsible for conducting approval tests and of Type Approval Authorities
12. Transitional provisions

Annexes

1 Communication

2 Arrangements of approval marks

Appendix 1 Examples of separate UN Regulation No. 117 approval marks

Appendix 2 Approval according to Regulation No. 117 coincident with approval of Regulation No. 30 or 54

Appendix 3 Combinations of markings of approvals issued in accordance with Regulations Nos. 117, 30 or 54

Appendix 4 Extensions to combine approvals issued in accordance with Regulation No. 117

3 Coast-by test method for measuring tyre-rolling sound emission

Appendix 1 Test report

4 Reserved

5 Test procedures for measuring the adhesion on wet surfaces of tyres in new state

Appendix Test reports examples of wet grip index for tyres in new state

6 Test procedure for measuring rolling resistance

Appendix 1 Test equipment tolerances

Appendix 2 (omitted)

Appendix 3 Test report and test data (Rolling resistance)

Appendix 4 Tyre standards organizations

Appendix 5 Deceleration method: Measurements and data processing for deceleration value obtaining in differential form dω/dt

7 Procedures for snow performance testing relative to tyres for use in severe snow conditions

Appendix 1 Pictogram definition of "Alpine Symbol"

Appendix 2 Test reports and test data for classes C1 and C2 tyres

Appendix 3 Test reports and test data for class C3 tyres

8 Procedures for ice performance testing relative to ice grip tyres of class C1

Appendix 1 Pictogram definition of "Ice Grip Symbol"

Appendix 2 Test reports and test data for class C1 tyres

9 Procedure for determining the adhesion on wet surfaces of tyres in worn state

Appendix 1 Worn tyre preparation report example

Appendix 2 Test reports examples of wet grip index for tyres in worn state

10 Procedure for determining the abrasion performance of tyres of class C1

Appendix 1 Test method (a) - Accelerations calculation

Appendix 2 Test method (a) - Test report example for the vehicle method

Appendix 3- Test method (b) - Input of test cycle

Appendix 4 Test method (b) - Test equipment tolerances

Appendix 5 Test method (b) - Replacement of sandpaper surface

Appendix 6 Test method (b) - Example of a test report for indoor drum test method

1. Scope

1.1. This Regulation applies to new pneumatic tyres* of classes C1, C2 and C3 in new state with regard to their sound emissions, rolling resistance and to adhesion performance on wet surfaces (wet adhesion) and for class C1 tyres in worn state with regard to adhesion performance on wet surfaces (wet adhesion). It also applies to C1 tyres in new state with regards to their tyre abrasion as defined in paragraph 1.3. of this UN Regulation. It does not, however, apply to:

* For the purpose of this Regulation "tyres" means "pneumatic tyres".

1.1.1. Tyres designed as "Temporary use spare tyres" and marked "Temporary use only";

1.1.2. Tyres having a nominal rim diameter code ≤ 10 (or ≤ 254 mm) or ≥ 25 (or ≥ 635 mm);

1.1.3. Tyres designed for competition;

1.1.4. Tyres intended to be fitted to road vehicles of categories other than M, N and O; ([1])

1.1.5. Tyres fitted with additional devices to improve traction properties (e.g. studded tyres);

1.1.6. Tyres with a speed category less than 80 km/h (speed category symbol F);

1.1.7. Tyres designed only to be fitted to vehicles registered for the first time before 1 October 2000.

1.1.8. Professional off-road tyres.

1.2. Contracting Parties shall issue or accept approvals to rolling sound and/or adhesion of tyres in new state on wet surfaces and/or adhesion of tyres in worn state on wet surfaces and/or rolling resistance.

1.3. In the case of class C1 tyres, except ice grip tyres and tyres having a nominal rim diameter code ≤ 13, approval shall be supplemented with information on the abrasion level according to paragraphs 5.7 to 5.9 of this Regulation.

2. Definitions

For the purpose of this Regulation, in addition to the definitions contained in Regulations Nos. 30 and 54, the following definitions apply.

2.1. "*Type of tyre*" means tyres which do not differ in such essential characteristics as:

(a) The manufacturer's name;

(b) The tyre class (see paragraph 2.6. below);

(c) The tyre structure;

(d) The category of use: normal tyre, snow tyre and special use tyre;

(e) Whether tyre for use in severe snow conditions or not:

(f) For class C1 tyres, whether ice grip tyre or not;

(g) For classes C2 and C3 tyres, whether traction tyre or not;

(h) The tread pattern (see paragraph 3.2.1. of this Regulation).

([1]) v As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3), document ECE/TRANS/WP.29/78/Rev.4, para. 2. - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html.

2.2. "*Manufacturer*" means the person or body who is responsible to the Type Approval Authority (TAA) for all aspects of the type-approval and for ensuring the conformity of production.

2.3. "*Brand name/trademark*" means the identification of the brand or trademark as defined by the tyre manufacturer and marked on the sidewall(s) of the tyre. The brand name/trademark may be the same as that of the manufacturer.

2.4. Trade description/commercial name: means an identification of a range of tyres as given by the tyre manufacturer. It may coincide with the brand name/trademark.

2.5. "*Rolling sound emission*" means the sound emitted from the contact between the tyres in motion and the road surface.

2.6. "*Tyre class*" means one of the following groupings:

2.6.1. *Class C1 tyres*: tyres conforming to UN Regulation No. 30;

2.6.2. *Class C2 tyres*: tyres conforming to UN Regulation No. 54 and identified by a load capacity index in single formation lower or equal to 121 and a speed category symbol higher or equal to "N";

2.6.3. *Class C3 tyres*: tyres conforming to UN Regulation No. 54 and identified by:

(a) A load capacity index in single formation higher or equal to 122; or

(b) A load capacity index in single formation lower or equal to 121 and a speed category symbol lower or equal to "M".

2.7. "*Representative tyre size*" means the tyre size which is submitted to the test described in Annex 3 to this Regulation with regard to rolling sound emissions, or Annex 5 for adhesion on wet surfaces or Annex 6 for rolling resistance or Annex 9 for adhesion on wet surfaces of tyres in worn state to assess the conformity for the type approval of the type of tyre, or Annex 7 for measuring snow performance, or Annex 8 for measuring ice performance.

2.8. "*Temporary-use spare tyre*" means a tyre different from a tyre intended to be fitted to any vehicle for normal driving conditions; but intended only for temporary use under restricted driving conditions.

2.9. "*Tyres designed for competition*" means tyres intended to be fitted to vehicles involved in motor sport competition and not intended for non-competitive on-road use.

2.10. "*Normal tyre*" means a tyre intended for normal on-road use.

2.11. "*Reinforced tyre*" or "*extra load tyre*" of class C1 means a tyre structure designed to carry more load at a higher inflation pressure than the load carried by the corresponding standard version tyre at the standard inflation pressure as specified in ISO 4000-1:2021. ([2])

2.12. "*Traction tyre*" means a tyre in classes C2 or C3 bearing the inscription TRACTION and intended to be fitted primarily to the drive axle(s) of a vehicle to maximize force transmission in various circumstances.

2.13. "*Snow tyre*" means a tyre whose tread pattern, tread compound or construction is primarily designed to achieve in mud and/or snow conditions a performance better than that of a normal tyre with regard to its ability to initiate and control vehicle motion.

([2]) Class C1 tyres correspond to "passenger car tyres" in ISO 4000-1:2021.

2.13.1. "*Tyre for use in severe snow conditions*" means a snow tyre or a special use tyre whose tread pattern, tread compound or structure is specifically designed to be used in severe snow conditions and that fulfils the requirements of paragraphs 6.5. and 6.5.1. of this Regulation.

2.13.1.1. "*Ice grip tyre*" means a class C1 snow tyre that is classified as tyre for use in severe snow conditions and additionally designed to be used on road surfaces covered with ice and that fulfils the requirements of paragraph 6.5.2. of this Regulation.

2.14. "*Special use tyre*" means a tyre intended for mixed use both on- and off-road or for other special duty. These tyres are primarily designed to initiate and maintain the vehicle in motion in off-road conditions.

2.15. "*Professional off-road tyre*" is a special use tyre primarily used for service in severe off-road conditions.

2.16. "*Tread depth*" means the depth of the principal grooves.

2.16.1. "*Principal grooves*" means the wide circumferential grooves positioned in the central zone of the tyre tread, which, in the case of passenger and light truck (commercial) tyres, have the treadwear indicators located in the base.

2.17. "*Void-to-fill ratio*" means the ratio between the area of voids in a reference surface and the area of this reference surface calculated from the mould drawing.

2.18 "*Standard Reference Test Tyre*" or "*SRTT*" means a tyre that is produced, controlled and stored in accordance with the standards of ASTM International:

(a) E1136 – 19 for the size P195/75R14 and referred to as "SRTT14";

(b) F2493 – 23 for the size P225/60R16 and referred to as "SRTT16";

(c) F3611 – 22e1 for the size P225/60R16 in worn state and referred to as "moulded SRTT16 worn";

(d) F2872 – 19 for the size 225/75R16C and referred to as "SRTT16C";

(e) F2871 – 23 for the size 245/70R19.5 and referred to as "SRTT19.5";

(f) F2870 – 23 for the size 315/70R22.5 and referred to as "SRTT22.5";

(g) F3678 – 23 for the size 245/70R19.5 and referred to as "SRTT19.5 siped";

(h) F3677 – 23 for the size 315/70R22.5 and referred to as "SRTT22.5 siped";

(i) F3676 – 23 for the size 225/45R17 and referred to as "SRTT17S";

(j) F3675 – 23 for the size 225/45R17 and referred to as "SRTT17W".

2.19. Wet adhesion or snow performance or ice performance measurements – Specific definitions

2.19.1. "*Adhesion on wet surfaces*" or "*wet adhesion*" means the relative braking performance, on a wet surface, of a test vehicle equipped with the candidate tyre in comparison to that of the same test vehicle equipped with a Standard Reference Test Tyre (SRTT).

2.19.2. "*Candidate tyre*" or "*candidate tyre set*" means a tyre or a tyre set, representative of the type that is submitted for approval in accordance with this Regulation and whose performances are evaluated relative to that of a reference tyre or reference tyre set.

2.19.3. "*Reference tyre*" or "*reference tyre set*" means a tyre or a tyre set of Standard Reference Test Tyres as defined in the respective annex.

2.19.4. "*Control tyre*" or "*control tyre set*" means a normal production tyre or a normal production tyre set that is used to establish the wet adhesion level or snow performance level or ice performance level of tyre sizes unable to be fitted to the same vehicle as the reference tyre or reference tyre set – see paragraph 2.2.2.8. of Annex 5, part (B), paragraph 3.4.3. of Annex 7 and paragraph 2.4.5.1.1. of Annex 8 to this Regulation.

2.19.5. "*Test tyre*" means a candidate tyre, reference tyre or control tyre.

2.19.6. "*Wet grip index*" *(G)* means the dimensionless unit for expressing the wet adhesion level of a candidate tyre relative to that of the applicable SRTT.

2.19.7. "*Snow grip index*" *(SG)* means the dimensionless unit for expressing the snow performance level of a candidate tyre relative to the performance of the applicable SRTT.

2.19.8. "*Ice grip index*" *(G_I)* means the dimensionless unit for expressing the ice performance level of a candidate tyre relative to the performance of the applicable SRTT.

2.19.9. "*Peak brake force coefficient ("pbfc")*" means the maximum value of the ratio of braking force to vertical load on the tyre prior to wheel lock-up.

2.19.10. "*Mean fully developed deceleration ("mfdd")*" means the average deceleration calculated on the basis of the measured distance recorded when decelerating a vehicle between two specified speeds.

2.19.11. "*Coupling (hitch) height*" means the height when measured perpendicularly from the centre of the articulation point of the trailer towing coupling or hitch to the ground, when the towing vehicle and trailer are coupled together. The vehicle and trailer shall be standing on level pavement surface in its test mode complete with the appropriate tyre(s) to be used in the particular test.

2.19.12. "*Test run*" means a single pass of a loaded tyre over a given test surface.

2.19.13. "*Braking test*" means a series of a specified number of test runs of the same test tyre repeated within a short time frame.

2.19.14. "*Traction test*" means a series of a specified number of spin-traction test runs of the same tyre repeated within a short time frame.

2.19.15. "*Acceleration test*" means a series of specified number of traction controlled acceleration test runs of the same tyre repeated within a short timeframe.

2.19.16. "*Test cycle*" means a series of braking tests, traction tests or acceleration tests that consist of an initial test of the reference tyre or the control tyre, of tests of candidate tyres and/or control tyres and a final test of the same reference tyre or control tyre.

2.19.17. "*Tyre in worn state*" or "*worn tyre*" means the tyre in a state as defined in Annex 9 to this Regulation.

2.19.18. "*Tyre in new state*" means the tyre in a state as defined in Annex 9 to this Regulation.

2.20. Rolling resistance measurement - Specific definitions

2.20.1. "*Rolling resistance*" (F_r) means the loss of energy (or energy consumed) per unit of distance travelled. ([3])

([3]) The International System of Units (SI) unit conventionally used for the rolling resistance is the newton-metre per metre, which is equivalent to a drag force in newtons.

2.20.2. "*Rolling resistance coefficient*" (C_r) means the ratio of the rolling resistance to the load on the tyre. ([4])

2.20.3. "*New test tyre*" means a tyre which has not been previously used in a rolling deflected test which elevates the tyre's temperature to higher than that generated in rolling resistance tests, and which has not previously been exposed to a temperature above 40 °C. ([5]) ([6])

2.20.4. "*Laboratory control tyre*" means a tyre used by an individual laboratory to control machine behaviour as a function of time. ([7])

2.20.5. "*Capped inflation*" means the process of inflating the tyre to the required cold inflation pressure and allowing the inflation pressure to build up, as the tyre is warmed up while running.

2.20.6. "*Parasitic loss*" means the loss of energy (or energy consumed) per unit distance excluding internal tyre losses, attributable to aerodynamic loss of the different rotating elements of the test equipment, bearing friction and other sources of systematic loss which may be inherent in the measurement.

2.20.7. "*Skim test reading*" means a type of parasitic loss measurement, in which the tyre is kept rolling without slippage, while reducing the tyre load to a level at which energy loss within the tyre itself is virtually zero.

2.20.8. "*Inertia*" or "*moment of inertia*" means the ratio of the torque applied to a rotating body, such as a tyre assembly or machine drum, to the rotational acceleration of this body. ([8])

2.20.9. "*Measurement reproducibility*" (σ_m) means the capability of a machine to measure rolling resistance. ([9])

2.21. Abrasion performance - Specific definitions

2.21.1. "*Abrasion rate*" means the ratio of mass of material lost from the tyre due to the abrasion process per distance travelled, and expressed in mg/km.

2.21.2. "*Abrasion level*" means the abrasion rate normalized to the load on the tyre, and expressed in mg/km/t.

([4]) The rolling resistance is expressed in newtons and the load is expressed in kilo-newton. The rolling resistance coefficient is dimensionless.

([5]) New test tyre definition is needed to reduce potential data variation and dispersion due to tyre aging effects.

([6]) It is permissible to repeat an accepted test procedure.

([7]) An example of machine behaviour is drift.

([8]) The rotating body can be, for example, a tyre assembly or machine drum.

([9]) Measurement reproducibility σ_m shall be estimated by measuring n times (where n ≥ 3), on a single tyre, the whole procedure described in paragraph 4. of Annex 6 as follows:

$$\sigma_m = \sqrt{\frac{1}{n-1} \cdot \sum_{j=1}^{n} \left(Cr_j - \frac{1}{n} \cdot \sum_{j=1}^{n} Cr_j \right)^2}$$

Where:

j = is the counter from 1 to n for the number of repetitions of each measurement for a given tyre,

n = number of repetitions of tyre measurements (n ≥ 3).

2.21.3. "*Abrasion index*" (AICT) of candidate tyre means the dimensionless unit for expressing the tyre abrasion level of a tyre relative to that of the applicable Standardized Reference Test Tyre (SRTT).

3. Application for approval

3.1. The application for approval of a type of tyre with regard to this Regulation shall be submitted by the tyre manufacturer or by his duly accredited representative. It shall specify:

3.1.1. The performance characteristics to be assessed for the type of tyre; "rolling sound emissions level" and/or "adhesion performance level on wet surfaces" of a tyre in new state" and/or "adhesion performance level on wet surfaces of a tyre in worn state" and/or "rolling resistance level"; "snow performance level" in case of tyre for use in severe snow conditions and additionally "ice performance level" in case of ice grip tyre;

3.1.1.1. In case of class C1 tyres, the information on the abrasion level, if reported, shall be communicated in the format according to the test report sheet of Appendix 2 or Appendix 6 of Annex 10;

3.1.2. Manufacturer's name and address;

3.1.3. If applicable, name and address of manufacturer's representative;

3.1.4. Tyre class (Class C1, C2 or C3) (see paragraph 2.6. of this Regulation);

3.1.5. Category of use (normal, snow, or special);

3.1.5.1. Whether tyre for use in severe snow conditions or not;

3.1.5.2. For classes C2 and C3 tyres, whether traction tyre or not;

3.1.5.3. For class C1 tyres, whether ice grip tyre or not;

3.1.6. Tyre structure;

3.1.7. Brand name(s)/trademark(s), trade description(s)/commercial name(s);

3.1.8. A list of tyre size designations covered by this application and specifying for each brand name/trademark and/or each trade description/commercial name the applicable tyre size designations and service descriptions, adding in case of class C1 tyres whether "reinforced" (or "extra load") or not.

3.2. The application for approval shall be accompanied (in triplicate) by:

3.2.1. Details of the major features, with respect to the effects on the performance (i.e. rolling sound emission level, adhesion on wet surfaces, rolling resistance, snow performance, ice performance, and tyre abrasion) of the tyres, including the tread pattern, included in the designated range of tyre sizes. This may be by means of descriptions supplemented by technical data, drawings, photographs or Computer Tomography (CT) scans, and must be sufficient to allow the Type Approval Authority or Technical Service to determine whether any subsequent changes to the major features will adversely affect the tyre performance. The effects of changes to minor details of tyre construction on tyre performances will be evident and determined during checks on conformity of production;

3.2.2. Drawings or photographs of the tyre sidewall, showing the approval marks referred to in paragraph 4., shall be submitted once the production has been established, but no later than one year after the date of granting of type approval;

3.2.3. In the case of applications relating to special use tyres, a copy of the mould drawing of the tread pattern shall be supplied in order to allow verification of the void-to-fill ratio.

3.3. At the request of the Type Approval Authority, the applicant shall submit samples of tyres for test or copies of test reports from the Technical Services, communicated as given in paragraph 11. of this Regulation.

3.4. With regard to the application, testing may be confined to a representative tyre size of the type of tyre, at the discretion of the Type Approval Authority.

4. Markings

4.1. All tyres constituting the type of tyre shall be marked as prescribed by either Regulation No. 30 or 54, as applicable.

4.2. In particular tyres shall bear: ([10])

4.2.1. The manufacturer's name or the brand name/trademark;

4.2.2. The trade description/commercial name (see paragraph 2.4. of this Regulation). However, the trade description is not required when it coincides with the brand name/trademark;

4.2.3. The tyre size designation;

4.2.4. The inscription "REINFORCED" (or alternatively "EXTRA LOAD") if the tyre is classified as reinforced;

4.2.5. The inscription "TRACTION" ([11]) if the tyre is classified as "traction tyre";

4.2.6. The "Alpine Symbol" ("3-peak-mountain with snowflake" conforming to the pictogram described in Annex 7, Appendix 1) if the snow tyre or the special use tyre is classified as tyre for use in severe snow conditions;.

4.2.6.1. The "Ice Grip Symbol" (conforming to the pictogram described in Annex 8, Appendix 1) if the tyre for use in severe snow conditions is additionally classified as ice grip tyre;

4.2.6.2. The inscription "M+S" or "M.S" or "M&S" if the special use tyre is classified as tyre for use in severe snow conditions in addition to the "Alpine Symbol";

4.2.7. The inscription "MPT" (or alternatively "ML" or "ET") and /or "POR" if the tyre is classified in the category of use "special".

ET means Extra Tread, ML stands for Mining and Logging, MPT means Multi-Purpose Truck and POR means Professional Off-Road.

4.3. Tyres shall provide adequate space for the approval mark as shown in Annex 2 to this Regulation.

4.3.1. In case the approval of a tyre pursuant to this Regulation has been granted by the same Type Approval Authority than that granting the approval pursuant to Regulation No. 30 or Regulation No. 54, the approval mark pursuant to Regulation No. 30 or Regulation No. 54 can be combined with an indication of the applicable series of amendments to which the tyre was approved pursuant to Regulation No. 117 on the form of 2 digits (example "04" indicating that the Regulation No.117 approval was granted following the 0~~4~~ series of amendments) and the suffixes according to paragraph 5.2.2. using the addition sign "+", as described in Annex 2, Appendix 3 of this Regulation, for example "0236378 + 0~~4~~S2W2R3B".

([10]) Some of these requirements may be specified separately in Regulation No. 30 or 54.
([11]) Minimum height of marking: refer to dimension C in Annex 3 of Regulation No. 54.

4.4. The markings referred to in paragraph 4.2. and the approval mark prescribed in paragraph 5.4. of this Regulation shall be clearly legible, indelible and raised above or sunk below the tyre surface.

4.4.1. The approval mark shall be situated in the lower area of the tyre on at least one of its sidewalls. However, in the case of tyres identified by the "tyre to rim fitment configuration" symbol "A" or "U", the markings may be located anywhere on the outside sidewall of the tyre.

5. Approval

5.1. If the representative tyre size of the type of tyre submitted for approval pursuant to this Regulation meets the requirements of paragraphs 6. and 7. below, approval of that type of tyre shall be granted.

5.2. An approval number according to Schedule 4 to the Revision 3 of the 1958 Agreement shall be assigned to the type of tyre approved. The same Contracting Party may not assign the same number to another type of tyre.

5.2.1. Instead of granting the original type approval number pursuant to UN Regulation No. 117, upon the request of the manufacturer, the Type Approval Authority may grant the type approval number, which had been granted before to that type of tyre pursuant to UN Regulations Nos. 30 or 54 with the subsequent extension number.

5.2.2. The communication form mentioned in paragraph 5.3. below shall identify specific performance parameters of UN Regulation No. 117 by the following suffixes:

S To identify additional conformity to the requirements on tyre rolling sound emissions;

W To identify additional conformity to the requirements on adhesion on wet surfaces of tyres in new state;

R To identify additional conformity to the requirements on tyre rolling resistance;

B To identify additional conformity to the requirements on adhesion on wet surfaces of tyres in worn state.

S will be followed by the suffix "2" for compliance to stage 2 while, taking into account that two stages are defined for adhesion on wet surfaces of tyres in new state and rolling resistance requirements in paragraphs 6.2. and 6.3. below, W will be followed either by the suffix "1" for compliance to stage 1 or by the suffix "2" for compliance to stage 2 and R will be followed either by the suffix "2" for compliance to stage 2 or by the suffix "3" for compliance to stage 3.

5.3. Notice of approval or extension of approval or refusal of approval of a type of tyre pursuant to this Regulation shall be communicated to the Parties to the Agreement, which apply this Regulation by means of a form conforming to the model in Annex 1 to the Regulation.

5.3.1. With reference to paragraph 5.2.1. above, tyre manufacturers are entitled to submit an application for extension of type approval to the requirements of other Regulations relevant to the type of tyre. In that case, a copy of the relevant type approval communication(s), as issued by the relevant Type Approval Authority, shall be attached to the application for extension of approval. Extension of approval(s) shall only be granted by the Type Approval Authority which issued the original approval for the tyre.

5.3.1.1. When extension of approval is granted to incorporate into the communication form (see Annex 1 to this Regulation) certification(s) of conformity to other Regulations, (all) the specific type approval number(s) and the Regulation itself shall be added to item 9. of Annex 1 "Communication".

5.3.1.2. The suffix(es) mentioned in paragraph 5.2.2. above shall be preceded by the two digits identifying the series of amendments of the prescription on tyre performances for Regulation No. 117, e.g. 04S2 to identify the fourth series of amendments on tyre road rolling sound emissions at stage 2 or 04S2W2R3B to identify the fourth series of amendments on tyre road rolling sound emissions at stage 2, adhesion on wet surfaces of a tyre in new state at stage 2, rolling resistance at stage 3 and adhesion on wet surfaces of a tyre in worn state.

5.4. In the space referred to in paragraph 4.3. and in accordance with the requirements of paragraph 4.4. above there shall be affixed to every tyre size, conforming to the type of tyre approved under this Regulation, an international approval mark consisting of:

5.4.1. A circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval; ([12]) and

5.4.2. The part of the approval number specified in paragraph 3 Section 3 of Schedule 4 to the Revision 3 of the 1958 Agreement, which shall be placed close to the circle prescribed in paragraph 5.4.1. above either above or below the "E" or to the left or right of that letter.

5.4.3. The suffix(es), and the identification to the relevant series of amendments, if any, as specified in the communication form.

One of the suffixes listed below or any combination of them can be used.

S2	Rolling sound emission level at stage 2
W1	Wet adhesion level in new state at stage 1
W2	Wet adhesion level in new state at stage 2
R2	Rolling resistance level at stage 2
R3	Rolling resistance level at stage 3
B	Wet adhesion level of tyres in worn state

These suffixes shall be placed to the right or below the approval number, if part of the original approval.

If the approval is extended subsequent to UN Regulations Nos. 30 or 54 approvals, the addition sign "+" and the series of amendment to UN Regulation No. 117 shall be placed in front of the suffix or any combination of suffixes to denote an extension to the approval.

If the approval is extended subsequent to the original approval under UN Regulation No. 117, the addition sign "+" shall be placed between the suffix or any combination of suffixes of the original approval and the suffix or any combination of suffixes added to denote an extension to the approval.

5.4.4. The marking on the tyre sidewalls of suffix(es) to the approval number removes the requirement for any additional marking on the tyre of the specific type approval number for conformity to the Regulation(s) to which the suffix refers as per paragraph 5.2.2. above.

5.5. If the tyre conforms to type approvals under one or more other Regulations annexed to the Agreement in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 5.4.1. above need not be repeated. In such a case the additional numbers and symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed adjacent to the symbol prescribed in paragraph 5.4.1. above.

([12]) The distinguishing numbers of the Contracting Parties to the 1958 Agreement are reproduced in Annex 3 to the Consolidated Resolution on the Construction of Vehicles (R.E.3), document ECE/TRANS/WP.29/78/Rev. 4, Annex 3 - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html.

5.6. Annex 2 to this Regulation gives examples of arrangements of approval marks.

5.7. Until 6 July 2026 and upon request of the applicant, during the approval of new type of class C1 tyres, it will be possible to determine the tyre abrasion level of one tyre of the tyre type in accordance with Annex 10 to this Regulation. The test results shall be communicated to the Type Approval Authority in the format according to the test report sheet of Appendix 2 or Appendix 6 of Annex 10.

5.8. Between 7 July 2026 and 31 December 2026 and upon request of the applicant, during the approval of new type of class C1 tyres, it will be possible to determine the tyre abrasion level of the tyre type determined in accordance with Annex 10 to this Regulation. The test results shall be communicated to the Type Approval Authority in the format according to the test report sheet of Appendix 2 or Appendix 6 of Annex 10.

5.9. Starting from 1 January 2027, the manufacturer, during the approval of new type of class C1 tyres, shall communicate the tyre abrasion level of the tyre type determined in accordance with Annex 10 to this Regulation. The test results shall be communicated to the Type Approval Authority in the format according to the test report sheet of Appendix 2 or Appendix 6 of Annex 10.

5.10. Abrasion tests are not required for extensions of existing type approvals according to this Regulation first granted before 1 January 2027.

6. Requirements

6.1. Rolling sound emission limits, as measured by the method described in Annex 3 to this Regulation.

6.1.1. For class C1 tyres, the rolling sound emission value shall not exceed the values given below. These values refer to the nominal section width as defined in UN Regulation No. 30:

Stage 2	
Nominal section width	Limit dB(A)
185 and lower	70
Over 185 up to 245	71
Over 245 up to 275	72
Over 275	74

The above limits shall be increased by 1 dB(A) for snow tyres that are classified as tyre for use in severe snow conditions, extra load tyres or reinforced tyres, or any combination of these classifications.

6.1.2. For class C2 tyres, the rolling sound emission value with reference to its category of use (see paragraph 2.1., subparagraph (d) above) shall not exceed the values given below:

Stage 2			
Category of use		Limit dB(A)	
		Other	Traction tyres
Normal tyre		72	73
Snow tyre		72	73
	Snow tyre that is classified as tyre for use in severe snow conditions	73	75

Stage 2			
Category of use		Limit dB(A)	
		Other	Traction tyres
Special use tyre		74	75
	Special use tyre that is classified as tyre for use in severe snow conditions	74	75

6.1.3. For class C3 tyres, the rolling sound emission value with reference to its category of use (see paragraph 2.1., subparagraph (d) above) shall not exceed the values given below:

Stage 2			
Category of use		Limit dB(A)	
		Other	Traction tyres
Normal tyre		73	75
Snow tyre		73	75
	Snow tyre that is classified as tyre for use in severe snow conditions	74	76
Special use tyre		75	77
	Special use tyre that is classified as tyre for use in severe snow conditions	75	77

6.2. The wet adhesion of tyres in new state will be determined based on a procedure that compares either peak brake force coefficient ("pbfc") or mean fully developed deceleration ("mfdd") against values achieved by a Standard Reference Test Tyre (SRTT). The relative performance shall be indicated by a wet grip index (G).

6.2.1. For Class C1 tyres, tested in accordance with either procedure given in Annex 5, Part (A), to this Regulation, the tyre shall meet the following requirements:

Stage 1		
Category of use		Wet grip index (G)
Normal tyre		≥ 1,1
Snow tyre		≥ 1,1
	Snow tyre that is classified as tyre for use in severe snow conditions and with a speed category greater than 160 km/h	≥ 1,0
	Snow tyre that is classified as tyre for use in severe snow conditions and with a speed category not greater than 160 km/h	≥ 0,9
Special use tyre		Not defined
	Special use tyre that is classified as tyre for use in severe snow conditions	Not defined

Stage 2			
Category of use			Wet grip index (G)
Normal tyre			≥ 1,2
Snow tyre			≥ 1,2
	Snow tyre that is classified as tyre for use in severe snow conditions	Speed category greater than 160 km/h	≥ 1,1
		Speed category not greater than 160 km/h	≥ 1,0
		Ice grip tyres	≥ 1,0
Special use tyre			≥ 1,1
	Special use tyre that is classified as tyre for use in severe snow conditions		≥ 1,0

6.2.2. For Class C2 tyres, tested in accordance with either procedure given in Annex 5, Part (B), to this Regulation, the tyre shall meet the following requirements:

Stage 1			
Category of use		Wet grip index (G)	
		Other	Traction tyres
Normal tyre		≥ 0,95	≥ 0,85
Snow tyre		≥ 0,95	≥ 0,85
	Snow tyre that is classified as tyre for use in severe snow conditions	≥ 0,85	≥ 0,85
Special use tyre		≥ 0,85	≥ 0,85
	Special use tyre that is classified as tyre for use in severe snow conditions	≥ 0,85	≥ 0,85

Stage 2			
Category of use		Wet grip index (G)	
		Other	Traction tyres
Normal tyre		≥ 1,10	≥ 1,00
Snow tyre		≥ 1,10	≥ 1,00
	Snow tyre that is classified as tyre for use in severe snow conditions	≥ 1,00	≥ 1,00
Special use tyre		≥ 1,00	≥ 1,00
	Special use tyre that is classified as tyre for use in severe snow conditions	≥ 1,00	≥ 1,00

6.2.3. For Class C3 tyres, tested in accordance with either procedure given in Annex 5, Part (B), to this Regulation, the tyre shall meet the following requirements:

Stage 1

Category of use		Wet grip index (G)	
		Other	Traction tyres
Normal tyre		≥ 0,80	≥ 0,65
Snow tyre		≥ 0,65	≥ 0,65
	Snow tyre that is classified as tyre for use in severe snow conditions	≥ 0,65	≥ 0,65
Special use tyre		≥ 0,65	≥ 0,65
	Special use tyre that is classified as tyre for use in severe snow conditions	≥ 0,65	≥ 0,65

Stage 2

Category of use		Wet grip index (G)	
		Other	Traction tyres
Normal tyre		≥ 0,95	≥ 0,80
Snow tyre		≥ 0,80	≥ 0,80
	Snow tyre that is classified as tyre for use in severe snow conditions	≥ 0,80	≥ 0,80
Special use tyre		≥ 0,80	≥ 0,80
	Special use tyre that is classified as tyre for use in severe snow conditions	≥ 0,80	≥ 0,80

6.3. Rolling resistance coefficient (C_r) limits, as measured by the method described in Annex 6 to this Regulation.

The maximum value of the rolling resistance coefficient shall not exceed the values given below (value in N/kN is equivalent to value in kg/tonne):

Stage 2

Tyre class	Max value of C_r (N/kN)
C1	10,5
C2	9,0
C3	6,5

For snow tyre that is classified as tyre for use in severe snow conditions, the limits shall be increased by 1 N/kN.

Stage 3				
Tyre class				Max value of C_r (N/Kn?
C1	load capacity index < 87			10,0
	load capacity index ≥ 87	Tyres other than Run Flat Tyres or Extended Mobility Tyres		9,0
			Tyres with a nominal aspect ratio ≤ 40 and suitable for speeds ≥ 300 km/h	10,0
		Run Flat Tyres or Extended Mobility Tyres		10,0
	Special use tyres			10,0
C2	Tyres other than Traction tyres			8,5
	Traction tyres			9,0
C3	Tyres other than tyres marked with “C”, “CP” or “LT”			6,0
	Tyres marked with “C” or “CP” as suffix to the tyre-size designation or with “LT” either as prefix or suffix to the tyre-size designation or with “LT” placed after the service description			6,5

For snow tyre that is classified as tyre for use in severe snow conditions, the limits shall be increased by 1 N/kN.

6.4. The wet adhesion of tyres in worn state shall be based on a procedure defined in Annex 9 to this Regulation.

6.4.1. For class C1 tyres, tested in accordance with either procedure given in Annex 9 to this Regulation, the tyre shall meet the following requirements:

Category of use			Wet grip index (G_B)
Normal tyre			≥ 0,88
	Tyre with a nominal aspect ratio equal to or less than 40, a section width equal to or higher than 235 mm and suitable for speeds equal to or greater than 300 km/h		≥ 0,80
Snow tyre			≥ 0,88
	Snow tyre that is classified as tyre for use in severe snow conditions suitable for speeds greater than 160 km/h		≥ 0,80
		Ice grip tyre	≥ 0,70
	Snow tyre that is classified as tyre for use in severe snow conditions suitable for speeds equal to or less than 160 km/h		≥ 0,70
		Ice grip tyre	≥ 0,70
Special use tyre			≥ 0,80
	Special use tyre that is classified as tyre for use in severe snow conditions		≥ 0,80

For normal tyres with speed category symbol indicating a maximum permissible speed equal to or greater than 300 km/h and aspect ratio equal to or lower than 40, the limit shall be decreased by 0.08.

6.4.2. For class C2 tyres, evaluated in accordance with the procedure given in paragraph 3. of Annex 9 to this Regulation, the tyre shall meet the following requirements:

Category of use		Wet grip index (G_B)	
		Other	Traction tyres
Normal tyre		≥ 0,82	≥ 0,74
Snow tyre		≥ 0,82	≥ 0,74
	Snow tyre that is classified as tyre for use in severe snow conditions	≥ 0,74	≥ 0,74
Special use tyre		≥ 0,74	≥ 0,74
	Special use tyre that is classified as tyre for use in severe snow conditions	≥ 0,74	≥ 0,74

6.4.3. For class C3 tyres, evaluated in accordance with the procedure given in paragraph 3. of Annex 9 to this Regulation, the tyre shall meet the following requirements:

Category of use		Wet grip index (G_B)	
		Other	Traction tyres
Normal tyre		≥ 0,66	≥ 0,54
Snow tyre		≥ 0,54	≥ 0,54
	Snow tyre that is classified as tyre for use in severe snow conditions	≥ 0,54	≥ 0,54
Special use tyre		≥ 0,54	≥ 0,54
	Special use tyre that is classified as tyre for use in severe snow conditions	≥ 0,54	≥ 0,54

6.5. In order to be classified as a tyre for use in severe snow conditions the tyre shall meet the performance requirements of paragraph 6.5.1. below. The tyre shall meet these requirements based on a test method of Annex 7 by which:

(a) The mean fully developed deceleration ("mfdd") in a braking test;

(b) Or alternatively an average traction force in a traction test;

(c) Or alternatively the average acceleration in an acceleration test

of the candidate tyre is compared to that of a Standard Reference Test Tyre (SRTT).

The relative performance shall be indicated by a snow grip index.

6.5.1. Snow performance requirements for classes C1, C2 and C3 tyres

The minimum snow grip index value, as calculated in the procedure described in Annex 7 and compared with the respective Standard Reference Test Tyre SRTT shall be as follows:

Class of tyre	Snow grip index (brake on snow method) [a]		Snow grip index (spin traction method) [b]	Snow grip index (acceleration method) [c]
	Ref.s = SRTT14, SRTT16	*Ref. = SRTT16C*	*Ref. = SRTT14, SRTT16*	*Ref.s =SRTT19.5, SRTT22.5, SRTT19.5 siped, SRTT22.5 siped*
C1	1,07	No	1,10	No
C2	No	1,02	1,10	No
C3	No	No	No	1,25

[a] See paragraph 3. of Annex 7 to this Regulation
[b] See paragraph 2. of Annex 7 to this Regulation
[c] See paragraph 4. of Annex 7 to this Regulation

6.5.2. Ice performance requirements for class C1 tyres classified as ice grip tyre

In order to be classified as ice grip tyre, a tyre for use in severe snow conditions shall meet the minimum ice grip index value, as calculated in the procedure described in Annex 8 and compared with the respective Standard Reference Test Tyre (SRTT) shall be as follows:

Class of tyre	Ice grip index
	Ref. = SRTT16
C1	1.18

6.6. In order to be classified as a "traction tyre", a tyre is required to meet at least one of the below reported conditions of paragraph 6.6.1. or 6.6.2.

6.6.1. The tyre shall have a tread pattern with minimum two circumferential ribs, each containing a minimum of 30 block-like elements, separated by grooves and/or sipe elements the depth of which has to be minimum of one half of the tread depth.

6.6.2. The tyre shall have a total number (n_{TE}) of traction elements of its tread pattern is equal to or greater than a limit that is calculated based on the deformation potential (P_{def}) of its tread pattern pursuant to paragraph 6.6.2.3.

6.6.2.1. Calculation of the deformation potential of the tread pattern

The "deformation potential" (P_{def}) is calculated as follows:

$$P_{def} = R_{void} \bullet {d_{tr}}^3$$

where:

R_{void} is a dimensionless figure between 0 and 1 representing the void-to-fill ratio of the tread pattern according to the definition in paragraph 2.17.;

d_{tr} is the maximum of the tread depths as defined in paragraph 2.16. of this Regulation expressed in millimetres.

The deformation potential P_{def} is expressed in mm^3.

6.6.2.2. Calculation of the number of traction elements

"Traction elements" (TE) are elements of the tread pattern which are completely separated from each other by grooves and/or sipes, on all their edges, at tread surface.

The total number n_{TE} of traction elements is calculated as follows

$$n_{TE} = \frac{1}{2} \bullet (n_{TE,50} + n_{TE,70})$$

where:

$n_{TE,50}$ is the number of traction elements separated by grooves/sipes with a depth equal to or greater than 50% of the maximum tread depth;

$n_{TE,70}$ is the number of traction elements separated by grooves/sipes with a depth equal to or greater than 70% of the maximum tread depth.

For the avoidance of doubt, each traction element counted within $n_{TE,70}$ is also counted within $n_{TE,50}$.

6.6.2.3. In order to be classified as a traction tyre, the total number of traction elements in the tread pattern of a tyre shall, depending on tyre class and, for class C3 tyres, nominal rim diameter, fulfil the respective condition:

For class C2 tyres: $n_{TE} \geq -\frac{2}{25\ \text{mm}^3} \bullet P_{def} + 100$

For class C3 tyres with nominal rim diameter code less than 20:

$$n_{TE} \geq -\frac{1}{10\ mm^3} \bullet P_{def} + 200$$

For class C3 tyres with nominal rim diameter code equal to or greater than 20:

If $P_{def} < 1400\ \text{mm}^3$: $n_{TE} \geq -\frac{17}{70\ mm^3} \bullet P_{def} + 400$

If $P_{def} \geq 1400\ \text{mm}^3$: $n_{TE} \geq -\frac{1}{10\ mm^3} \bullet P_{def} + 200$

6.7. In order to be classified as a "special use tyre" a tyre shall have a block tread pattern in which the blocks are larger and more widely spaced than for normal tyres and have the following characteristics:

For class C1 tyres: a tread depth ≥ 9 mm and void-to-fill ratio ≥ 30 per cent;

For class C2 tyres: a tread depth ≥ 11 mm and void-to-fill ratio ≥ 35 per cent;

For class C3 tyres: a tread depth ≥ 16 mm and void-to-fill ratio ≥ 35 per cent

6.8. In order to be classified as a "professional off-road tyre", a tyre shall have all of the following characteristics:

(a) For classes C1 and C2 tyres:

(i) A tread depth ≥ 11 mm;

(ii) A void-to-fill ratio ≥ 35 per cent;

(iii) A maximum speed category symbol of ≤ Q.

(b) For class C3 tyres:

(i) A tread depth ≥ 16 mm;

(ii) A void-to-fill ratio ≥ 35 per cent;

(iii) A maximum speed category symbol of ≤ K.

7. Modifications of the type of tyre and extension of approval

7.1. Every modification of the type of tyre, which may influence the performance characteristics approved in accordance with this Regulation, shall be notified to the Type Approval Authority which approved the type of tyre. That Authority may either:

7.1.1. Consider that the modifications are unlikely to have any appreciable adverse effect on the performance characteristics approved and that the tyre will comply with the requirements of this Regulation; or

7.1.2. Require further samples to be submitted for test or further test reports from the designated Technical Service.

7.2. Confirmation or refusal of approval, specifying the modifications, shall be communicated by the procedure given in paragraph 5.3. of this Regulation to the Parties to the Agreement which apply this Regulation.

7.3. The Type Approval Authority granting the extension of approval shall assign a series number for such an extension which shall be shown on the communication form.

8. Conformity of production

The conformity of production procedures shall comply with those set out in the 1958 Agreement, Schedule 1 (E/ECE/324-E/ECE/TRANS/505/Rev.3) with the following requirements :

8.1. Any tyre approved under this Regulation shall be so manufactured as to conform to the performance characteristics of the type of tyre approved and satisfy the requirements of paragraph 6. above;

8.2. The authority which has granted type approval may at any time verify the conformity control methods applied by the manufacturer. In general, the conformity control methods should take into consideration the production volumes of the type of tyre at each manufacturing facility. The normal frequency of these verifications shall be at least once every two years.

8.3. Verification tests shall be carried out on random samples of tyres bearing the approval mark required by this Regulation taken from the series production. Where the test procedure involves testing a number of tyres at the same time, for example a set of four tyres for the purpose of measuring wet adhesion in accordance with the standard vehicle procedure given in Annex 5 to this Regulation, then the set shall be considered as being one unit for the purposes of calculating the number of tyres to be tested. The Type Approval Authority shall satisfy itself that all tyres falling within an approved type comply with the approval requirement.

8.3.1. In the case of verification tests with regard to approvals in accordance with paragraph 6.2. of this Regulation, these shall be carried out using the same testing method (see Annex 5 to this Regulation) as that adopted for original approval.

8.3.2. In the case of verification tests with regard to approvals in accordance with paragraph 6.5. of this Regulation, these shall be carried out using the same testing method (see Annex 7 to this Regulation) as that adopted for original approval.

8.3.2.1. In the case of verification tests with regard to approvals of tyres of class C3 in accordance with paragraph 6.5.1. of this Regulation, these may be carried out, upon request of the tyre manufacturer, using the same reference tyre (see Annex 7 to this Regulation) as that adopted for the original approval.

8.3.3. In the case of verification tests with regard to approvals in accordance with paragraph 6.4. of this Regulation, these shall be carried out using the same testing method (see Annex 9 to this Regulation) as that adopted for the original approval.

8.3.4. In the case of verification tests with regard to approvals in accordance with paragraph 6.1. of this Regulation, these may be carried out, upon request of the tyre manufacturer, using the same temperature correction formula (see Annex 3 to this Regulation) as that adopted for the original approval.

8.4. Production shall be deemed to conform to the requirements of this Regulation if the levels measured comply with the limits prescribed in paragraph 6.1. of this Regulation, with an additional allowance of +1 dB(A) for possible mass production variations.

8.5. Production shall be deemed to conform to the requirements of this Regulation if the levels measured comply with the limits prescribed in paragraph 6.3. of this Regulation, with an additional allowance of +0.3 N/kN for possible mass production variations.

9. Penalties for non-conformity of production

9.1. The approval granted in respect of a type of tyre pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 8. above are not complied with, or if any tyre of the type of tyre exceeds the limits given in paragraphs 8.4. or 8.5. above.

9.2. If a Party to the Agreement, which applies this Regulation, withdraws an approval, it has previously granted, it shall forthwith notify the other Contracting Parties applying this Regulation by means of a copy of the communication form conforming to the model in Annex 1 to this Regulation.

10. Production definitively discontinued

If the holder of an approval completely ceases to manufacture a type of tyre approved in accordance with this Regulation, he shall so inform the Type Approval Authority, which granted the approval. Upon receiving the relevant communication that Authority shall inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

11. Names and addresses of Technical Services responsible for conducting approval tests and of Type Approval Authorities

11.1. The Contracting Parties to the 1958 Agreement which apply this Regulation shall communicate to the United Nations Secretariat, the names and addresses of the Technical Services responsible for conducting approval tests and, where applicable, of the approved test laboratories and of the Type Approval Authorities which grant approval and to which forms certifying approval or extension of approval or refusal of approval or withdrawal of approval, or production definitively discontinued, issued in other countries, are to be sent.

11.2. The Contracting Parties to the 1958 Agreement which apply this Regulation may designate laboratories of tyre manufacturers as approved test laboratories.

11.3. Where a Contracting Party to the 1958 Agreement applies paragraph 11.2. Above, it may, if it so desires, be represented at the tests by one or more persons of its choice.

12. Transitional provisions

12.1. As from the official date of entry into force of the 04 series of amendments, no Contracting Party applying this Regulation shall refuse to grant or refuse to accept type approvals under this Regulation as amended by the 04 series of amendments.

12.2. As from 7 July 2024, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued according to any preceding series of amendments, first issued after 7 July 2024.

12.3. As from 7 July 2024, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued according to the 04 series of amendments to this Regulation, first issued after 7 July 2024, if the stage 2 requirements for wet adhesion in new state set out in paragraph 6.2. and the stage 3 requirements for rolling resistance set out in paragraph 6.3. are not complied with.

12.4. Until 6 July 2026, Contracting Parties applying this Regulation shall accept type approvals issued according to the 02 or the 03 series of amendments, first issued before 7 July 2024.

12.5. As from 7 July 2026, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued according to any preceding series of amendments to this Regulation.

12.6. Until the dates given below, Contracting Parties applying this Regulation shall accept type approvals issued according to the 04 series of amendments to this Regulation, first issued before 7 July 2024, if the stage 2 requirements for wet adhesion in new state set out in paragraph 6.2. and the stage 3 requirements for rolling resistance set out in paragraph 6.3. are not complied with.

Tyre class	Date
C1	6 July 2026
C2 and C3	31 August 2028

12.7. As from the dates given below, Contracting Parties applying this Regulation shall not be obliged to accept type approval issued according to the 04 series of amendments to this Regulation, if the stage 2 requirements for wet adhesion in new state set out in paragraph 6.2. and the stage 3 requirements for rolling resistance set out in paragraph 6.3. are not complied with.

Tyre class	Date
C1	7 July 2026
C2 and C3	1 September 2028

12.8. Contracting Parties applying this Regulation may grant type approvals according to any preceding series of amendments to this Regulation.

12.8.1. Contracting Parties applying this Regulation shall continue to grant extensions of existing approvals to any preceding series of amendments to this Regulation.

12.9. Until 1 September 2024, Contracting Parties applying this Regulation may continue to grant type approvals according to the 04 series of amendments to this Regulation, based on snow performance test described in Annex 7 to this Regulation using SRTT14 as reference tyre. ([13])

12.10. Until 1 September 2024, Contracting Parties applying this Regulation may continue to grant type approvals according to the 04 series of amendments to this Regulation, based on the test procedures for measuring the wet adhesion of tyres in new state as described in Annex 5 of this Regulation, without taking into account the provisions introduced after Supplement 12 to the 02 series of amendments.

([13]) SRTT14 will be available from the supplier until end of October 2021.

12.11. Until 6 July 2024, Contracting Parties applying this Regulation may continue to grant type approvals of class C1 tyres according to the 04 series of amendments to this Regulation, based on the test procedures for measuring the wet adhesion of tyres in worn state as described in Annex 9 to this Regulation using buffed SRTT16 in worn state as reference tyre.

12.12. Notwithstanding paragraph 12.11., Contracting Parties applying this Regulation shall continue to grant extensions to existing type approvals of class C1 tyres according to the 04 series of amendments to this Regulation first granted before 7 July 2024, based on the test procedures for measuring the wet adhesion of tyres in worn state as described in Annex 9 to this Regulation using buffed SRTT16 in worn state as reference tyre. In case a new test has to be performed on a different representative tyre size for an extension to be granted after 7 July 2024, the moulded SRTT16 worn shall be used.

12.13. Until 60 months from the entry into force of Supplement 15 to the 02 series of amendments, Contracting Parties applying this Regulation shall continue to grant type approvals and extension to existing type approvals according to the 04 series of amendments to this Regulation, based on tyre-rolling sound emissions tests performed on test sites the surface and the dimensions of which is in accordance with ISO 10844:2014.

12.14. As from 7 July 2024, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued according to the 04 series of amendments to this Regulation, first issued after 7 July 2024, if, in the case of classes C2 and C3 traction tyre, the requirements for traction classification set out in paragraph 6.6.2. are not complied with.

12.15. Until 31 August 2030, Contracting Parties applying this Regulation shall accept type approvals and grant extension to type approvals issued according to the 04 series of amendments to this Regulation, first issued before 7 July 2024, if, in the case of classes C2 and C3 traction tyre, the requirements for traction classification set out in paragraph 6.6.2. are not complied with.

12.16. As from 1 September 2030, Contracting Parties applying this Regulation shall not be obliged to accept type approvals of tyres issued according to the 04 series of amendments to this Regulation if, in the case of classes C2 and C3 traction tyre, the requirements for traction classification set out in paragraph 6.6.2. are not complied with.

12.17. Until 6 January 2029, Contracting Parties applying this Regulation shall continue to allow fitting on a vehicle in use of new tyres manufactured prior to the date set out in paragraph 12.5. and approved to this Regulation as amended by the 02 or 03 series of amendments.

12.18. Until 6 July 2025, Contracting Parties applying this Regulation shall continue to grant type approvals based on the tyre-rolling sound emissions using only the temperature correction formula specified in Annex 3, paragraph 4.2.1.

12.19. As from 7 July 2025, Contracting Parties applying this Regulation shall grant type approvals based on the tyre-rolling sound emissions using only the temperature correction formula specified in Annex 3, paragraph 4.2.2.

12.20. Contracting Parties applying this Regulation shall continue to grant extensions to existing type approvals first granted before 7 July 2025 based on the tyre-rolling sound emissions using the temperature correction formula specified in Annex 3, paragraph 4.2.1. In case a new test has to be performed on a different representative tyre size for an extension to be granted after 6 July 2025, the temperature correction formula specified in Annex 3, paragraph 4.2.2. shall be used.

12.21. As from 1 September 2028, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued according to Supplement 2 to the 04 series of amendments to this Regulation, based on the test procedures for measuring the wet adhesion of tyres in new state as described in Annex 5 to this Regulation using one of the two equivalent Standard Reference Test Tyres SRTT19.5 and SRTT22.5 as tyre reference, first issued after 31 August 2028.

12.22. As from 1 September 2028, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued according to Supplement 2 to the 04 series of amendments to this Regulation, based on snow performance tests as described in Annex 7 to this Regulation using one of the two equivalent Standard Reference Test Tyres SRTT19.5 and SRTT22.5 as tyre reference, first issued after 31 August 2028.

12.23. Notwithstanding paragraph 12.21., Contracting Parties applying this Regulation shall continue to grant extensions to existing type approvals of class C3 tyres according to the 04 series of amendments to this Regulation first granted before 1 September 2028, based on the test procedures for measuring the wet adhesion of tyres in new state as described in Annex 5 to this Regulation using one of the two equivalent Standard Reference Test Tyres SRTT19.5 and SRTT22.5 as reference tyre. In case a new test has to be performed on a different representative tyre size for an extension to be granted after 1 September 2028, the SRTT19.5 siped or SRTT22.5 siped shall be used.

12.24. Notwithstanding paragraph 12.22., Contracting Parties applying this Regulation shall continue to grant extensions to existing type approvals of class C3 tyres according to the 04 series of amendments to this Regulation first granted before 1 September 2028, based on snow performance test described in Annex 7 to this Regulation using either SRTT19.5 or SRTT22.5 as reference tyre. In case a new test has to be performed on a different representative tyre size for an extension to be granted after 01 September 2028, the SRTT19.5 siped or SRTT22.5 siped shall be used.

12.25. As from the entry into force of that supplement until 31 August 2028, Contracting Parties applying this Regulation shall accept type approvals issued according to Supplement 2 to the 04 series of amendments to this Regulation, first issued before 1 September 2028, if the track characteristics for measuring wet adhesion of tyre in new state are established using the following reference tyres:

Tyre class	Reference tyres
C2	SRTT16 or SRTT 16C
C3	SRTT16 or SRTT19.5 or SRTT22.5 or SRTT19.5 siped or SRTT22.5 siped

12.26. As from the 1 September 2028, Contracting Parties applying this Regulation shall not be obliged to accept type approval issued according to Supplement 2 to the 04 series of amendments to this Regulation, if the track characteristics for measuring wet adhesion of tyre in new state are not established using the following reference tyres:

Tyre class	Reference tyres
C2	SRTT16C
C3	SRTT19.5 siped or SRTT22.5 siped

ANNEX 1

Communication

(Maximum format: A4 (210 × 297 mm))



Issued by: Name of administration:
……
……
……

Concerning: (2) Approval granted
Approval extended
Approval refused
Approval withdrawn
Production definitively discontinued

of a type of tyre with regard to "rolling sound emission level" and/or "adhesion performance on wet surfaces" and/or "rolling resistance" pursuant to UN Regulation No. 117

Approval No (3) …… Suffix(es) (4) ……

1. Manufacturer's name and address: ……

2. If applicable, name and address of manufacturer's representative: ……

3. "Tyre class" of the type of tyre: ……

4. "Category of use" of the type of tyre: ……

4.1. Tyre for use in severe snow conditions (Yes/No) (2)

4.1.1. Ice grip tyre (Yes/No) (2)

4.2. Traction tyre (Yes/No) (2)

5. Tyre structure: ……

6. Type of tyre designation: ……

6.1. Brand name(s)/trademark(s) of the type of tyre:

6.2. Trade description(s)/commercial name(s) of the type of tyre:

(1) Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).
(2) Strike out what does not apply.
(3) According to paragraphs 5.2.2. and 5.3.1.2. of this Regulation.
(4) According to Schedule 4 to Revision 3 of the 1958 Agreement.

7. Technical service and, where applicable, test laboratory approved for purposes of approval or of verification of conformity tests: .....

8. Performance(s) approved: rolling sound emission level at stage 2, wet adhesion level of tyres in new state at (stage 1/ stage 2) ([5]), rolling resistance level at (stage 2/stage 3) ([5]), wet adhesion level of tyres in worn state

8.1. Sound level of the representative tyre size, see paragraph 2.7. of this Regulation, as per item 7. of the test report in Appendix 1 to Annex 3: … dB(A) at reference speed of 70 km/h or 80 km/h ([5])

8.2. Wet adhesion level of tyres in new state of representative size, see paragraph 2.7. of this Regulation, as per the test report examples shown in the appendix to Annex 5: … (G) using the vehicle or trailer method ([5])

8.3. Wet adhesion level of tyres in worn state of representative size, see paragraph 2.7. of this Regulation, as per the test report in the appendix to Annex 9 in the case of class C1 tyres or as per evaluation performed according to paragraph 3. of Annex 9 in the case of classes C2 and C3 tyres ([5]): … (GB) using the vehicle or trailer method ([5])

8.4. Rolling resistance level of the representative tyre size, see paragraph 2.7. of this Regulation, as per item 7. of the test report in Appendix 1 to Annex 6

8.5. Snow performance level of the representative tyre size, see paragraph 2.7. of Regulation No. 117, as per item 7. of the test report in the appendix ([6]) to Annex 7:… (snow grip index) using the brake on snow method ([5]), spin traction method ([5]) or acceleration method ([5])

8.5.1. Ice performance level of the representative tyre size, see paragraph 2.7. of Regulation No. 117, as per item 7. of the test report in the appendix 2 to Annex 8: … (ice grip index) using the brake on ice method ([5])

8.6. Abrasion level available in the case of class C1 tyres (Yes/No) ([5])

8.6.1. Use of the vehicle on public open roads method ([5]) or the indoor drum method ([5])

9. Number of report issued by the Technical Service: .....

10. Date of report issued by that Service: .....

11. Reason(s) of extension (if applicable): .....

12. Any remarks: .....

13. Place: .....

14. Date: .....

15. Signature: .....

16. Annexed to this communication are: .....

([5]) Strike out what does not apply.
([6]) Appendix 2 for classes C1 and C2 tyres. Appendix 3 for class C3 tyres.

16.1. A list of documents in the approval file deposited at the Type Approval Authorities having delivered the approval and which can be obtained upon request. ([7])

16.2. A list of tyre size designations: Specify for each brand name/trademark and/or each trade description/commercial name the list of tyre size designations and service descriptions, adding in case of class C1 tyres whether "reinforced" (or "extra load") or not.

([7]) In the case of tyre for use in severe snow conditions a test report according to Appendix 2 or Appendix 3, as applicable, to Annex 7 shall be submitted. Additionally in the case of ice grip tyre a test report according to Appendix 2 to Annex 8 shall be submitted.

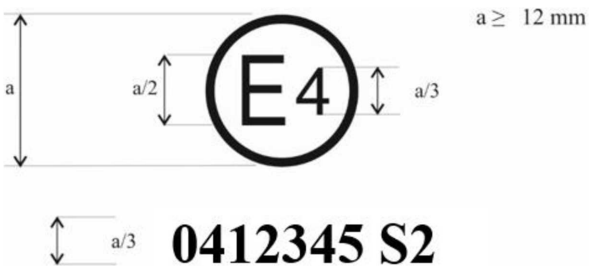
ANNEX 2

Arrangements of approval marks

Annex 2 - Appendix 1

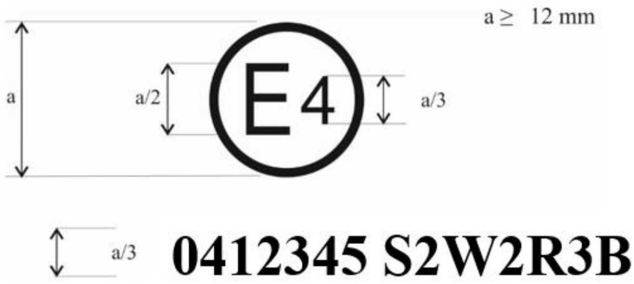
Examples of separate UN Regulation No. 117 approval marks

Example 1



The above approval mark, affixed to a pneumatic tyre shows that a tyre concerned has been approved in the Netherlands (E 4) pursuant to Regulation No. 117 (marked by S2 (rolling sound at stage 2) only), under approval number 0412345. The first two digits of the approval number (04) indicate that the approval was granted according to the requirements 04 series of amendments to this Regulation.

Example 2

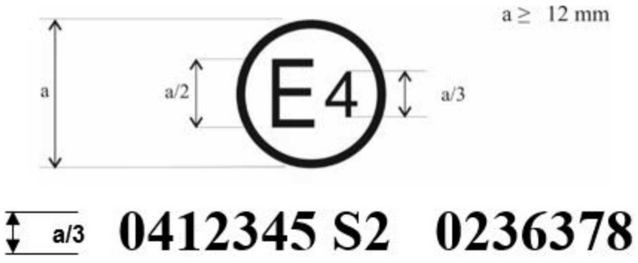


The above approval mark shows that the tyre concerned has been approved in the Netherlands (E 4) pursuant to Regulation No. 117 (marked by S2 (rolling sound at stage 2) W2 (wet adhesion of tyres in new state at stage 2), R3 (Rolling resistance at stage 3) and B (wet adhesion of tyres in worn state)) under approval number 0412345. The first two digits of the approval number (04) indicate that the approval was granted according to the requirements of the 04 series of amendments to this Regulation.

Annex 2 - Appendix 2

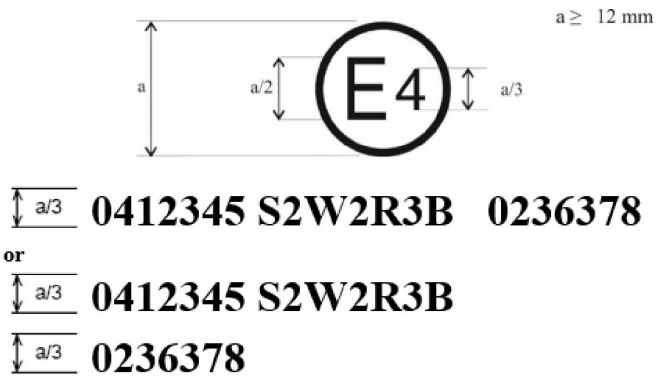
Approval according to Regulation No. 117 coincident with approval of Regulation No. 30 or 54

Example 1



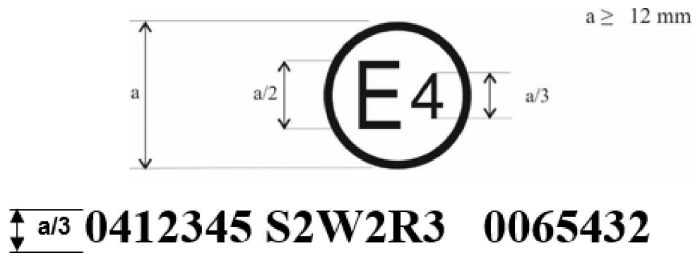
The above approval mark shows that the tyre concerned has been approved in the Netherlands (E 4) pursuant to UN Regulation No. 117 (marked by "S2" (rolling sound at stage 2)), under approval number 0412345 and UN Regulation No. 30, under approval number 0236378. The first two digits of the approval number ("04" and "02") indicate that the approval pursuant to UN Regulation No. 117 was granted according to the 04 series of amendments and the approval pursuant to UN Regulation No. 30 according to the 02 series of amendments.

Example 2



The above approval mark shows that the tyre concerned has been approved in the Netherlands (E 4) pursuant to UN Regulation No. 117 (marked by "S2W2R3B" (rolling sound emission at stage 2, wet adhesion of tyres in new state at stage 2, rolling resistance at stage 3 and wet adhesion of tyres in worn state)), under approval number 0312345 and UN Regulation No. 30 under approval number 0236378. The first two digits of the approval numbers ("04" and "02") indicate that the approval pursuant to UN Regulation No. 117 was granted according to the 04 series of amendments and the approval pursuant to UN Regulation No. 30 according to the 02 series of amendments.

Example 3

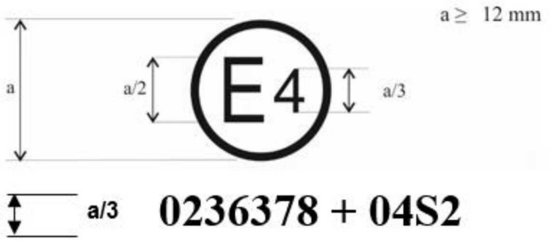


The above approval mark shows that the tyre concerned has been approved in the Netherlands (E4) pursuant to UN Regulation No. 117 (marked by "S2W2R3" (rolling sound emission at stage 2, wet adhesion of tyres in new state at stage 2 and rolling resistance at stage 3)), under approval number 0412345 and UN Regulation No. 54 under approval number 0065432. The first two digits of the approval numbers ("04" and "00") indicate that the approval pursuant to UN Regulation No. 117 was granted according to the 04 series of amendments and the approval pursuant to UN Regulation No. 54 according to its original form.

Annex 2 - Appendix 3

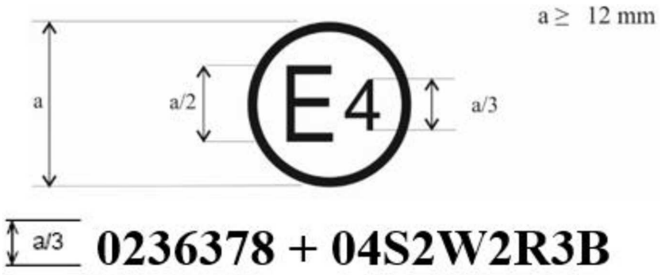
Combinations of markings of approvals issued in accordance with Regulations Nos. 117, 30 or 54

Example 1



The above approval mark shows that the tyre concerned has been approved in the Netherlands (E4) pursuant to UN Regulation No. 30 according to its 02 series of amendments (indicated by the first two digits of the approval number, "02") under approval number 0236378. It is also marked by "+ 04S2" which indicates that the tyre was also approved pursuant to UN Regulation No. 117 (04 series of amendments) for S (rolling sound emission at stage 2).

Example 2

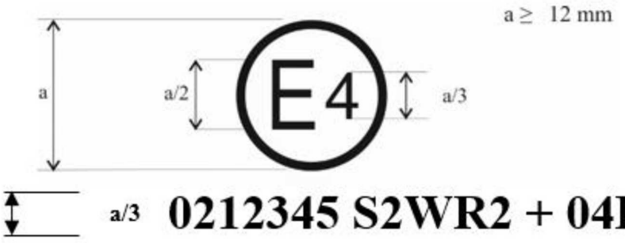


The above approval mark shows that the tyre concerned has been approved in the Netherlands (E4) pursuant to UN Regulation No. 30 according to its 02 series of amendments (indicated by the first two digits of the approval number, "02") under approval number 0236378. It is also marked by "+ 04S2W2R3B" which indicates that the tyre was also approved pursuant to UN Regulation No. 117 (04 series of amendments) for S (rolling sound emission at stage 2) W (wet adhesion of tyres in new state at stage 2), R (rolling resistance at stage 3) and B (wet adhesion of tyres in worn state).

Annex 2 - Appendix 4

Extensions to combine approvals issued in accordance with Regulation No. 117

Example 1



The above approval mark shows that the tyre concerned has been initially approved in the Netherlands (E4) pursuant to UN Regulation No. 117 (02 series of amendments) under approval number 0212345. The marking is complemented by S2WR2: S2 for rolling sound emission at stage 2, W for wet adhesion of tyres in new state and R2 for rolling resistance at stage 2. The "04B" preceded by "+" indicates that it has had its approval extended under UN Regulation No. 117 (04 series of amendments) to wet adhesion of tyres in worn state based on separate certificate.

ANNEX 3

Coast-by test method for measuring tyre-rolling sound emission

Introduction

The presented method contains specifications on measuring instruments, measurement conditions and the measurement method, in order to obtain the sound level of a set of tyres mounted on a test vehicle rolling on a specified road surface. The maximum sound pressure level is to be recorded, when the test vehicle is coasting, by remote-field microphones; the final result for a reference speed is obtained from a linear regression analysis. Such test results cannot be related to tyre rolling sound measured during acceleration under power or deceleration under braking.

1. Measuring instruments

1.1. Acoustic measurements

The sound level meter or the equivalent measuring system, including the windscreen recommended by the manufacturer shall meet or exceed the requirements of Type 1 instruments in accordance with IEC 61672-1:2013.

1.1.1. Calibration

At the beginning and at the end of every measurement session, the entire measurement system shall be checked by means of a sound calibrator that fulfils the requirements for sound calibrators of at least precision Class 1 according to IEC 60942:2017. Without any further adjustment the difference between the readings of two consecutive checks shall be less than or equal to 0.5 dB(A). If this value is exceeded, the results of the measurements obtained after the previous satisfactory check shall be discarded.

1.1.2. Compliance with requirements

The compliance of the sound calibration device with the requirements of IEC 60942:1988 shall be verified once a year and the compliance of the instrumentation system with the requirements of IEC 60651:1979/A1:1993, second edition shall be verified at least every two years, by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

1.1.3. Positioning of the microphone

The microphone (or microphones) shall be located at a distance of 7.5 ± 0.05 m from track reference line CC' (Figure 1) and 1.2 ± 0.02 m above the ground. Its axis of maximum sensitivity shall be horizontal and perpendicular to the path of the vehicle (line CC').

1.2. Speed measurements

The vehicle speed shall be measured with instruments with accuracy of ±1 km/h or better when the front end of the vehicle has reached line PP (Figure 1).

1.3. Temperature measurements

Measurements of air as well as test surface temperature are mandatory.

The temperature measuring devices shall be accurate within ±1 °C.

1.3.1. Air temperature

The temperature sensor is to be positioned in an unobstructed location close to the microphone in such a way that it is exposed to the airflow and protected from direct solar radiation. The latter may be achieved by any shading screen or similar device. The sensor should be positioned at a height of 1.2 ± 0.1 m above the test surface level, to minimize the influence of the test surface thermal radiation at low airflows.

1.3.2. Test surface temperature

The temperature sensor is to be positioned in a location where the temperature measured is representative of the temperature in the wheel tracks, without interfering with the sound measurement.

If an instrument with a contact temperature sensor is used, heat-conductive paste shall be applied between the surface and the sensor to ensure adequate thermal contact.

If a radiation thermometer (pyrometer) is used, the height should be chosen to ensure that a measuring spot with a diameter of ≥ 0.1 m is covered.

1.4. Wind measurement

The device shall be capable of measuring the wind speed with a tolerance of ±1 m/s. The wind shall be measured at microphone height. The wind direction with reference to the driving direction shall be recorded.

2. Conditions of measurement

2.1. Test site

The test site shall consist of a central section surrounded by a substantially flat test area. The measuring section shall be level; the test surface shall be dry and clean for all measurements. The test surface shall not be artificially cooled during or prior the testing.

The test track shall be such that the conditions of a free sound field between the sound source and the microphone are attained to within 1 dB(A). These conditions shall be deemed to be met if there is no large sound reflecting objects, such as fences, rocks, bridges or building within 50 m of the centre of the measuring section. The surface of the test track and the dimensions of the test site shall be in accordance with ISO 10844:2021.

A central part of at least 10 m radius shall be free of powdery snow, tall grass, loose soil, cinders or the like. There shall be no obstacle, which could affect the sound field within the vicinity of the microphone and no persons shall stand between the microphone and the sound source. The operator carrying out the measurements and any observers attending the measurements shall position themselves so as not to affect the readings of the measuring instruments.

2.2. Meteorological conditions

Measurements shall not be made under poor atmospheric conditions. It shall be ensured that the results are not affected by gusts of wind. Testing shall not be performed if the wind speed at the microphone height exceeds 5 m/s.

Measurements shall not be made if the air temperature is below 5 °C or above 40 °C or the test surface temperature is below 5 °C or above 50 °C.

2.3. Ambient noise

2.3.1. The background sound level (including any wind noise) shall be at least 10 dB(A) less than the measured tyre rolling sound emission. A suitable windscreen may be fitted to the microphone provided that account is taken of its effect on the sensitivity and directional characteristics of the microphone.

2.3.2. Any measurement affected by a sound peak which appears to be unrelated to the characteristics of the general sound level of tyres, shall be ignored.

2.4. Test vehicle requirements

2.4.1. General

The test vehicle shall be a motor vehicle and be fitted with four single tyres on just two axles.

2.4.2. Vehicle load

The vehicle shall be loaded such as to comply with the test tyre loads as specified in paragraph 2.5.2. below.

2.4.3. Wheelbase

The wheelbase between the two axles fitted with the test tyres shall for class C1 be less than 3.50 m and for class C2 and class C3 tyres be less than 5 m.

2.4.4. Measures to minimize vehicle influence on sound level measurements

To ensure that tyre rolling sound is not significantly affected by the test vehicle design the following requirements and recommendations are given.

2.4.4.1. Requirements:

(a) Spray suppression flaps or other extra device to suppress spray shall not be fitted;

(b) Addition or retention of elements in the immediate vicinity of the rims and tyres, which may screen the emitted sound, is not permitted;

(c) Wheel alignment (toe in, camber and caster) shall be in full accordance with the vehicle manufacturer's recommendations;

(d) Additional sound absorbing material may not be mounted in the wheel housings or under the underbody;

(e) Suspension shall be in such a condition that it does not result in an abnormal reduction in ground clearance when the vehicle is loaded in accordance with the testing requirement. If available, body level Regulation systems shall be adjusted to give a ground clearance during testing which is normal for unladen condition.

2.4.4.2. Recommendations to avoid parasitic noise:

(a) Removal or modification on the vehicle that may contribute to the background noise of the vehicle is recommended. Any removals or modifications shall be recorded in the test report;

(b) During testing it should be ascertained that brakes are not poorly released, causing brake noise;

(c) It should be ascertained that electric cooling fans are not operating;

(d) Windows and sliding roof of the vehicle shall be closed during testing.

2.5. Tyres

2.5.1. General

Four identical tyres shall be fitted on the test vehicle. In the case of class C3 tyres with a load capacity index in excess of 121 and without any dual fitting indication, two of these tyres of the same type and range shall be fitted to the rear axle of the test vehicle; the front axle shall be fitted with tyres of size suitable for the axle load and planed down to the minimum depth in order to minimize the influence of tyre/road contact noise while maintaining a sufficient level of safety.

In the case of class C2 tyres with a load capacity index lower or equal to 121, with a section width wider than 200 mm, an aspect ratio lower than 55, a rim diameter code lower than 15 and without any dual fitting indication, two of these tyres of the same type and range shall be fitted to the rear axle of the test vehicle; the front axle shall be fitted with tyres of a size suitable for the axle load and planed down to the minimum depth in order to minimize the influence of tyre/road contact noise while maintaining a sufficient level of safety.

Tyres with special fitting requirements shall be tested in accordance with these requirements (e.g. rotation direction). The tyres shall have full tread depth before being run-in.

Tyres are to be tested on rims permitted by the tyre manufacturer.

2.5.2. Tyre loads

The test load Q_t for each tyre on the test vehicle shall be 50 to 90 per cent of the reference load Q_r, but the average test load $Q_{t,avr}$ of all tyres shall be 75 ± 5 per cent of the reference load Q_r.

For all tyres the reference load Q_r corresponds to the maximum mass associated with the load capacity index of the tyre. In the case where the load capacity index is constituted by two numbers divided by slash (/), reference shall be made to the first number.

2.5.3. Tyre inflation pressure

Each tyre fitted on the test vehicle shall have a test pressure P_t not higher than the reference pressure P_r and within the interval:

$$P_r \times \left(\frac{Q_t}{Q_r}\right)^{1.25} \leq P_t \leq 1.1\ P_r \times \left(\frac{Q_t}{Q_r}\right)^{1.25}$$

For class C2 and class C3 the reference pressure P_r is the inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

For class C1 the reference pressure is P_r = 250 kPa for "standard" tyres and 290 kPa for "reinforced" or "extra load" tyres; the minimum test pressure shall be P_t = 150 kPa.

2.5.4. Preparations prior to testing

The tyres shall be "run-in" prior to testing to remove compound nodules or other tyre pattern characteristics resulting from the moulding process. This will normally require the equivalent of about 100 km of normal use on the road.

The tyres fitted to the test vehicle shall rotate in the same direction as when they were run-in.

Prior to testing tyres shall be warmed up by running under test conditions.

3. Method of testing

3.1. General conditions

For all measurements the vehicle shall be driven in a straight line over the measuring section (AA' to BB') in such a way that the median longitudinal plane of the vehicle is as close as possible to the line CC'.

When the front end of the test vehicle has reached the line AA' the vehicle driver shall have put the gear selector on neutral position and switched off the engine. If abnormal noise (e.g. ventilator, self-ignition) is emitted by the test vehicle during the measurement, the test shall be disregarded.

3.2. Nature and number of measurements

The maximum sound level expressed in A-weighted decibels (dB(A)) shall be measured to the first decimal place as the vehicle is coasting between lines AA' and BB' (Figure 1 - front end of the vehicle on line AA', rear end of the vehicle on line BB'). This value will constitute the result of the measurement.

At least four measurements shall be made on each side of the test vehicle at test speeds lower than the reference speed specified in paragraph 4.1. below and at least four measurements at test speeds higher than the reference speed. The speeds shall be approximately equally spaced over the speed range specified in paragraph 3.3. below.

3.3. Test speed range

The test vehicle speeds shall be within the range:

(a) From 70 to 90 km/h for class C1 and class C2 tyres;

(b) From 60 to 80 km/h for class C3 tyres.

4. Interpretation of results

The measurement shall be invalid if an abnormal discrepancy between the values is recorded (see paragraph 2.3.2. of this Annex).

4.1. Determination of test result

Reference speed V_{ref} used to determine the final result will be:

(a) 80 km/h for class C1 and class C2 tyres;

(b) 70 km/h for class C3 tyres.

4.2. Temperature correction

4.2.1. Until the date indicated in paragraph 12.18. of this Regulation, for class C1 and class C2 tyres, the rolling sound levels $L_i(\vartheta_i)$ obtained at the test surface temperature ϑ_i (where *i* denotes the number of the single measurement) shall be normalized to a test surface reference temperature ϑ_{ref} by applying a temperature correction, according to the following formula:

$$L_i(\vartheta_{ref}) = L_i(\vartheta_i) + K(\vartheta_{ref} - \vartheta_i)$$

where:

ϑ_{ref} = 20 °C,

For class C1 tyres, the coefficient *K* is:

— 0.03 dB(A)/°C when $\vartheta_i > \vartheta_{ref}$ and

— 0.06 dB(A)/°C when $\vartheta_i < \vartheta_{ref}$.

For class C2 tyres, the coefficient K is –0.02 dB(A)/°C.

4.2.2. From the date indicated in paragraph 12.19., for class C1 and class C2 tyres, the rolling sound levels $L_i(\vartheta_i)$ obtained at the test surface temperature ϑ_i (where *i* denotes the number of the single measurement) shall be normalized to a test surface reference temperature ϑ_{ref} by applying a temperature correction, according to the following formula:

$$L_i(\vartheta_{ref}) = L_i(\vartheta_i) - K_1 \bullet \lg\left(\frac{\vartheta_{ref} + K_2}{\vartheta_i + K_2}\right)$$

where:

ϑ_{ref} = 20 °C,

and the coefficients K_1 and K_2 are given in the tables below.

Class C1 tyres	K_1 (°C)	K_2 (°C)
Tyres that are classified as tyre for use in severe snow conditions	1.35	2.29
Other tyres	2.25	0

Class C2 tyres	K_1 (°C)	K_2 (°C)
Tyres that are classified as tyre for use in severe snow conditions	0	0
Other tyres	1.22	0

4.2.3. Notwithstanding the above procedure, the temperature correction may be made only on the final reported tyre rolling sound level L_R, utilizing the arithmetic mean value of the measured temperatures, if the measured test surface temperature does not change more than 5 °C within all measurements necessary for the determination of the sound level of one set of tyres. In this case the regression analysis below shall be based on the uncorrected rolling sound levels $L_i(\vartheta_i)$.

There will be no temperature correction for class C3 tyres.

4.3. Regression analysis of rolling sound measurements

The tyre-road rolling sound level $L_R(\vartheta_{ref})$ in dB(A) is determined by a regression analysis according to:

$$L_R(\vartheta_{ref}) = \overline{L} - a \bullet \overline{\tau}$$

where:

$\overline{L}$ is the mean value of the temperature-corrected rolling sound levels $L_i(\vartheta_{ref})$, measured in dB(A):

$$\overline{L} = \frac{1}{n}\sum_{i=1}^{n} L_i(\vartheta_{\mathrm{ref}})$$

n is the number of measurements ($n \geq 16$),

$\overline{\tau}$ is the mean value of logarithms of speeds V_i:

$$\overline{\tau} = \frac{1}{n}\sum_{i=1}^{n} \tau_i \quad \text{with} \quad \tau_i = \log_{10}\left(\frac{V_i}{V_{\mathrm{ref}}}\right)$$

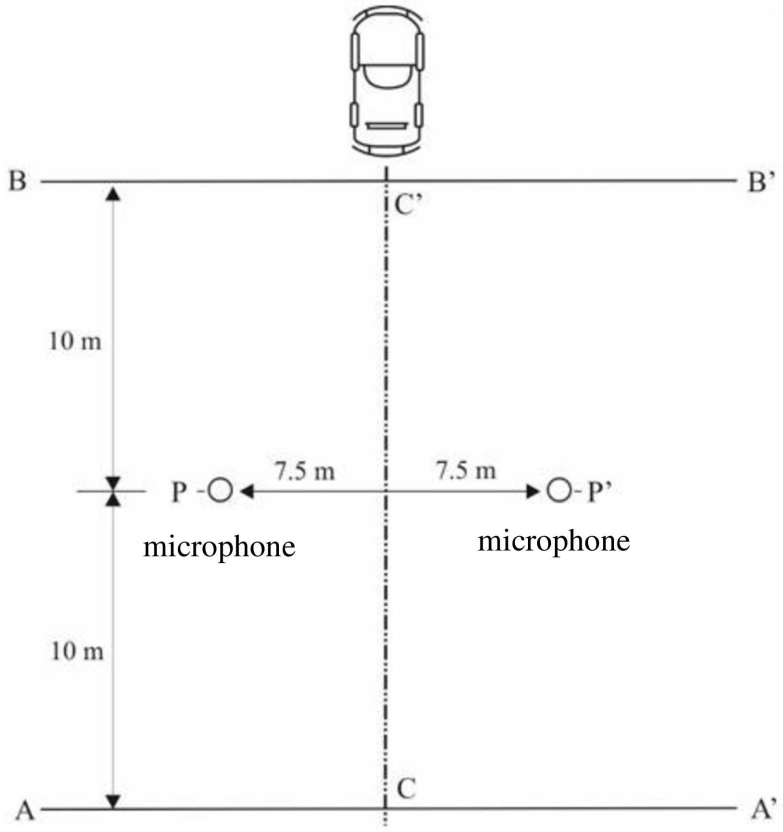
a is the slope of the regression line in dB(A):

$$a = \frac{\sum_{i=1}^{n}[(\tau_i - \overline{\tau})(L_i(\vartheta_{\mathrm{ref}}) - \overline{L})]}{\sum_{i=1}^{n}(\tau_i - \overline{\tau})^2}$$

4.4. In order to take account of any measuring instrument inaccuracies, the temperature corrected tyre rolling sound level $L_R(\vartheta_{ref})$ in dB(A) shall be reduced by 1 dB(A) and then rounded down to the nearest lower whole value to obtain the final result.

Figure 1

Microphone positions for the measurement



Annex 3 - Appendix 1

Test report

Part 1 - Report

1. Type Approval Authority or Technical Service: .....

2. Name and address of manufacturer: .....

.....

3. Test report No.: .....

4. Brand name and trade description: .....

5. Tyre Class (C1, C2 or C3): .....

6. Category of use: .....

6.1. Tyre for use in severe snow conditions (Yes/No)

6.2. Traction tyre (Yes/No)

7. Sound level according to paragraph 4.4. of Annex 3: .....dB(A)

at reference speed of 70/80 km/h [1]

8. Comments (if any): .....

.....

9. Date: .....

10. Signature:

.....

Part 2 - Test data

1. Date of test: .....

2. Test vehicle (make, model, year, modifications, etc.): .....

.....

2.1. Test vehicle wheelbase: ..... mm

3. Location of test track: .....

3.1. Date of track certification to ISO 10844:2014: .....

3.2. Issued by: .....

3.3. Method of certification: .....

4. Tyre test details: .....

4.1. Tyre size designation: .....

4.2. Tyre service description: .....

4.3. Reference (test) inflation pressure [2]: .....kPa

4.4. Test data: .....

	Front left	Front right	Rear center	Rear right
Test mass (kg)				
Tyre load capacity index (%)				
Inflation pressure (cold) (kPa)				

4.5. Test rim width code: .....

4.6. Temperature measurement sensor type: .....

[1] Strike out what does not apply.
[2] for classes C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

5. Valid test results: .....

Run No.	Test speed km/h	Direction of run	Sound level left [a] measured dB(A)	Sound level right [a] measured dB(A)	Air temp. °C	Test surface temp. °C	Sound level left [a] temp. corrected [b] dB(A)	Sound level righta [a] temp. corrected [b] dB(A)	Comments
1									
2									
3									
4									
5									
6									
7									
8									

[a] Relative to the vehicle.
[b] Omit, if regression according to paragraph 4.3. of Annex 3 is made on the uncorrected rolling sound level values.

5.1. Regression line slope: .....

5.2. Sound level according to paragraph 4.3. of Annex 3:

..... dB(A)

ANNEX 4

Reserved

ANNEX 5

Test procedures for measuring the adhesion on wet surfaces of tyres in new state

(A) — Class C1 tyres

1. Reference standards

The following documents listed apply.

1.1. ASTM E 965-96 (Reapproved 2006), Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique.

2. Definitions

In addition to the definitions in paragraph 2. of the main body of this Regulation, for the purposes of measuring wet adhesion of class C1 tyres:

2.1. "*Reference tyre*" or "*reference tyre set*" means a tyre or a tyre set of Standard Reference Test Tyres SRTT16.

2.2. "*Braking force*" means the longitudinal force, expressed in newtons, resulting from braking torque application.

2.3. "*Average braking force coefficient*" (BFC) means, for the vehicle method, the ratio of the average deceleration in a braking test to the acceleration due to gravity (rounded to 9.81 $m \cdot s^{-2}$).

2.4. "*Dynamic braking force coefficient*" ($\mu(t)$) means, for the trailer (or tyre test vehicle) method, the ratio of the braking force to the vertical load acquired in real time.

2.5. "*Peak braking force coefficient*" (μ_{peak}) means, for the trailer (or tyre test vehicle) method, the maximum value of the dynamic braking force coefficient that occurs prior to lockup of the wheel as the braking torque is progressively increased.

2.6. *"Lockup of a wheel"* means the condition of a wheel in which its rotational velocity about the wheel spin axis is zero and it is prevented from rotating in the presence of applied wheel torque.

2.7. "*Vertical load*" means the normal force, expressed in newtons, exerted on the road resulting from the mass supported by the tyre.

2.8. *"Tyre test vehicle"* means a dedicated special purpose vehicle which has instruments to measure the vertical and the longitudinal forces on one test tyre during braking.

2.9. "*Tyre set*" means, for the trailer (or tyre test vehicle) method, one (1) tyre and, for the vehicle method, four (4) tyres.

2.10. "*Instrumented passenger car*" means a commercialized passenger car equipped with an Antilock Braking System (ABS) and the measuring equipment listed in paragraph 4.1.2.2. of this Annex.

3. General test conditions

3.1. Track characteristics

The test track shall have the following characteristics:

3.1.1. The surface shall have a dense asphalt surface with a uniform gradient of not more than 2 per cent in both longitudinal and lateral directions and shall not deviate more than 6 mm when tested with a 3 m straight edge.

3.1.2. The surface shall have a pavement of uniform age, composition, and wear. The test surface shall be free of loose material and foreign deposits.

3.1.3. The maximum chipping size shall be 10 mm (tolerances permitted from 8 mm to 13 mm).

3.1.4. The average macro texture depth as measured in accordance with ASTM E965-96 (Reapproved 2006) by a sand patch shall be 0.7 ± 0.3) mm. In case the vehicle method is used, the average macro texture depth shall be determined in both lanes where the tyres are going to brake.

3.1.5. The wetted frictional properties of the surface shall be measured using the SRTT16 either with the method described in paragraph 3.2.1. of this Annex in case the vehicle method (according to paragraph 4.1. below) is used, or with the method described in paragraph 3.2.2. in this Annex in case the trailer (or tyre test vehicle) method is used.

3.2. Methods to measure the wetted frictional properties of the surface

3.2.1. Using the procedure described in paragraph 4.1. of this Annex, perform two braking tests of the reference tyre, each consisting of at least six (6) valid test runs in the same direction on aligned segments of the track. The braking tests shall cover the entire potential braking area, including where the texture depth was measured.

Evaluate the braking tests as described in paragraphs 4.1.6.1. and 4.1.6.2. of this Annex. one braking test CV_{BFC} exceeds 4 per cent, dismiss the results and repeat the braking tests.

For each braking test, the arithmetic mean $\overline{BFC_{ave}}$ of the average braking force coefficients shall be corrected for effects of temperature as follows:

$$BFC_{ave,corr} = \overline{BFC_{ave}} + a \bullet (\vartheta - \vartheta_0)$$

where

ϑ is the wetted surface temperature in degrees Celsius,

$a = \ 0.002\ °C^{-1}$ and $\vartheta_0 = 20\ °C$.

For each braking test, the temperature-corrected average braking force coefficient ($BFC_{ave,corr}$) shall be not less than 0.57 and not greater than 0.79.

The arithmetic means of the temperature-corrected average braking force coefficients of the two braking tests shall not differ by more than 10 per cent of the average of the two values:

$$CVal(BFC_{ave,corr}) = 2 \bullet \left| \frac{BFC_{ave,corr,1} - BFC_{ave,corr,2}}{BFC_{ave,corr,1} + BFC_{ave,corr,2}} \right| \leq 10\ \%$$

3.2.2. Using the procedure described in paragraph 4.2. of this Annex, perform in the same area where the average macro texture depth was measured one braking test of the reference tyre, consisting of at least six (6) valid test runs in the same direction.

Evaluate the braking test as described in paragraphs 4.2.8.1. and 4.2.8.2. of this Annex. If the coefficient of variation CV_{μ} exceeds 4 per cent, dismiss the results and repeat the braking test.

The arithmetic mean ($\overline{\mu_{peak}}$) of the measured peak braking force coefficients shall be corrected for effects of temperature as follows:

$$\mu_{peak,corr} = \overline{\mu_{peak}} + a \bullet (\vartheta - \vartheta_0)$$

where

ϑ is the wetted road surface temperature in degrees Celsius,

$a = 0.002\ °C^{-1}$ and $\vartheta_0 = 20\ °C$.

The temperature-corrected average peak braking force coefficient ($\mu_{peak,corr}$) shall be not less than 0.65 and not greater than 0.90.

3.3. Atmospheric conditions

The wind conditions shall not interfere with wetting of the surface (wind-shields are allowed).

The wetted surface temperature and the ambient temperature shall be between:

Category of use		Wetted surface temperature	Ambient temperature
Normal tyre		12 °C – 35 °C	12 °C – 40 °C
Snow tyre		5 °C – 35 °C	5 °C – 40 °C
	Snow tyre that is classified as tyre for use in severe snow conditions	5 °C – 20 °C	5 °C – 20 °C
Special use tyre		5 °C – 35 °C	5 °C – 40 °C
	Special use tyre that is classified as tyre for use in severe snow conditions	5 °C – 20 °C	5 °C – 20 °C

Moreover, the wetted surface temperature shall not vary during the test by more than 10 °C.

The ambient temperature shall remain close to the wetted surface temperature; the difference between the ambient and the wetted surface temperatures shall be less than 10 °C.

4. Testing methods for measuring wet adhesion

For the calculation of the wet grip index (G) of a candidate tyre, the wet grip braking performance of the candidate tyre is compared to the wet grip braking performance of the reference tyre on a vehicle travelling straight ahead on a wet, paved surface. It is measured with one of the following methods:

(a) Vehicle method consisting of testing a set of tyres mounted on an instrumented passenger car;

(b) Testing method using a trailer towed by a vehicle or a tyre test vehicle, equipped with the test tyre(s).

4.1. Testing method (a) using an instrumented passenger car

4.1.1. Principle

The testing method covers a procedure for measuring the deceleration performance of class C1 tyres during braking, using an instrumented passenger car.

Starting with a defined initial speed, the brakes are applied hard enough on four wheels at the same time to activate the ABS. The average deceleration is calculated between two pre-defined speeds.

4.1.2. Equipment

4.1.2.1. Vehicle

Any commercialized passenger car, preferably not older than 5 years, type approved pursuant to UN Regulation No. 13-H with regards to its braking system, which is fitted with an anti-lock system (ABS), shall be considered as suitable for the purpose of the test provided that the mechanical conditions of the passenger car meet the car manufacturer's recommendations and no warning from ABS (e.g. warning lights) is displayed.

Permitted modifications on the passenger car are as follows:

(a) Those allowing the number of tyre sizes that can be mounted on the vehicle to be increased;

(b) Those permitting automatic activation of the braking device to be installed;

(c) Those permitting the vehicle to be guided or accelerated externally.

Any other modification of the vehicle and specifically of the braking system is prohibited.

4.1.2.2. Measuring equipment

The exposed portions of the system shall tolerate 100 per cent relative humidity (rain or spray) and all other conditions, such as dust, shock and vibrations, which may be encountered in regular operation.

The vehicle shall be fitted with a sensor suitable for measuring speed on a wet surface and distance covered between two speeds.

To measure vehicle speed, a fifth wheel or non-contact precision (including e. g. radar, GPS, etc.) speed-measuring system shall be used.

The following tolerances shall be respected:

(a) For speed measurement: ± 1 % or ± 0.5 km/h, whichever is greater;

(b) For distance: $\pm 1 \bullet 10^{-1}$ m.

4.1.3. Conditioning of the test track and wetting condition

The test track surface shall be watered at least for half an hour prior to testing in order to equalize the surface temperature and water temperature. External watering should be supplied continuously throughout testing. For the whole testing area, the water depth shall be (1.0 ± 0.5) mm, measured from the peak of the pavement.

The test track should then be conditioned by conducting at least ten test runs with tyres not involved in the test programme at 90 km/h.

4.1.4. Tyres and rims

4.1.4.1. Tyre preparation and stabilization, rims and fitment on the vehicle

The test tyres shall be trimmed to remove all protuberances on the tread surface caused by mould air vents or flashes at mould junctions.

Fit the test tyres on rims specified by a recognized tyre and rim standards organization as listed in Appendix 4 to Annex 6 to this Regulation. Rim width code shall not differ by more than 0.5 from the measuring rim width code. Ensure proper bead seating by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

The tyres should be stabilized in performance prior to testing, which means that no evolution of the BFC value in test runs should be detectable; in any case there will be an ex-post verification according to paragraph 4.1.6.2. of this Annex. In all cases, tyre designed tread depth and designed tread block or rib integrity shall not change significantly with break-in, which means the pace and "severity" of the break-in needs to be carefully controlled to avoid such changes.

Place the fitted test tyres in a location such that they all have the same ambient temperature prior to testing and shield them from the sun to avoid excessive heating by solar radiation.

Maximum spacer (adapter) width allowed to mount tyres on the vehicle is 60 mm.

4.1.4.2. Tyre load

The static load on each axle tyre shall lie between 60 per cent and 90 per cent of the tested tyre load capacity. Tyre loads on the same axle should not differ by more than 10 per cent.

It is prohibited to exceed the maximum axle load of the vehicle.

4.1.4.3. Tyre inflation pressure

On the front axle, the inflation pressures p shall be calculated as follows:

$$p = p_{ref} \bullet \left(1.3 \bullet \frac{Q}{Q_{ref}}\right)^{1.25}$$

where

p_{ref} is the reference inflation pressure (250 kPa for standard-load and 290 kPa for extra-load versions, regardless of the reference pressure in the applicable standard);

Q is the average tyre vertical load on the front axle;

Q_{ref} is the reference vertical load associated with the load-capacity index.

On the rear axle, the inflation pressure shall be 220 kPa (for both standard-load and extra-load versions). The tyre pressure should be checked just prior to testing at ambient temperature and adjusted if required.

4.1.5. Procedure

4.1.5.1. Test run

The following test procedure applies for each test run.

4.1.5.1.1. The passenger car is driven in a straight line up to (85 ± 2) km/h.

4.1.5.1.2. Once the passenger car has reached (85 ± 2) km/h, the brakes shall always be activated at the same place on the test track referred to as "braking starting point", with a longitudinal tolerance of 5 m and a transverse tolerance of 0.5 m. Braking tests shall occur on the same lanes and in the same direction that was used to examine the surface, including where the macro texture depth was measured, in accordance with paragraphs 3.1.4. and 3.1.5. above (with a transverse tolerance of 0.5 m).

4.1.5.1.3. The brakes are activated either automatically or manually.

4.1.5.1.3.1. The automatic activation of the brakes is performed by means of a detection system made of two parts, one indexed to the test track and one on board the passenger car.

4.1.5.1.3.2. The manual activation of the brakes depends on the type of transmission as follows. In both cases, the pedal effort shall be high enough to activate the ABS.

For manual transmission, as soon as the driver is in the measuring zone and having reached (85 ± 2) km/h, the driver should release the clutch and depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

For automatic transmission, as soon as the driver is in the measuring zone and having reached (85 ± 2) km/h, the driver should select neutral gear and then depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

For each braking test and for tyres not tested before, the first two runs shall be discarded.

4.1.5.1.4. If any of the specifications listed above (including speed tolerance, longitudinal and transverse tolerance for the braking starting point, and braking time) are not met when a test run is made, the test run is invalidated and a new test run is made.

4.1.5.2. Braking test and test cycle

Within the same test cycle, each test run of each braking test shall be made in the same direction and in accordance with paragraph 4.1.5.1. of this Annex. Several test cycles may be performed consecutively, where the final braking test of the reference tyre set of a test cycle may serve as the initial braking test of the reference test tyre set for the next test cycle.

Up to three different candidate tyre sets may be measured within the same test cycle according to the following procedure:

4.1.5.2.1. Initial braking test of the reference tyre (R_i): First, the reference tyre set is mounted on the instrumented passenger car and at least four (4) valid test runs shall be made.

4.1.5.2.2. Braking test of a candidate tyre set (T_n): The reference tyre set is replaced by a candidate tyre set (T_n) and at least six (6) valid test runs of the candidate tyres shall be performed.

4.1.5.2.3. After the braking test of the first candidate tyre set, up to two more candidate tyre sets may be measured.

4.1.5.2.4. Final braking test of the reference tyres (R_f): The test cycle is closed by at least four (4) valid test runs of the same reference tyre set as at the beginning of the test cycle.

Examples:

(a) The run order for a test cycle of three candidate tyre sets (T_1 to T_3) would be the following:

$R_i - T_1 - T_2 - T_3 - R_f$

(b) The run order for a braking test (consisting of two test cycles) of five candidate tyre sets (T_1 to T_5) would be the following:

$R_i - T_1 - T_2 - T_3 - R_f / R_i - T_4 - T_5 - R_f$

4.1.6. Processing of measurement results

4.1.6.1. Calculation of the average braking force coefficient

For each valid test run *j*, the average braking force coefficient $BFC_{ave,j}$ is calculated from the distance d_j covered between 80 km/h and 20 km/h as follows:

$$BFC_{ave,j} = \frac{v_i^2 - v_f^2}{2 \bullet d_j \bullet g}$$

where:

v_f is the final speed in m/s; v_f = 20 km/h = 5.556 m/s

v_i is the initial speed in m/s; v_i = 80 km/h = 22.222 m/s

d_j is the distance covered in test run *j* between v_i and v_f in metres;

g is the acceleration due to gravity = 9.81 m•s^{-2}.

4.1.6.2. Validation of results

The coefficient of variation CV_{BFC} is calculated as follows:

$$CV_{BFC} = 100\% \bullet \frac{\sigma_{BFC}}{\overline{BFC_{ave}}}$$

where

$\sigma_{BFC} = \sqrt{\frac{1}{N-1} \Sigma_{j=1}^{N} (BFC_{ave,j} - \overline{BFC_{ave}})^2}$ denotes the corrected sample standard deviation and

$\overline{BFC_{ave}}$ the arithmetic mean of the average braking force coefficients $BFC_{ave,j}$ of *N* test runs.

For the reference tyre:

(a) The coefficient of variation CV_{BFC} of the initial and the final braking test of the reference tyre within one test cycle shall be less than or equal to 4 per cent.

(b) The arithmetic means of the average braking force coefficients of the initial and the final braking test shall not differ by more than 5 per cent of the average of the two values:

$$CVal(BFC_{ave}) = 100\% \bullet \ 2 \bullet \left| \frac{\overline{BFC_{ave}}(R_i) - \overline{BFC_{ave}}(R_f)}{\overline{BFC_{ave}}(R_i) + \overline{BFC_{ave}}(R_f)} \right| \leq 5\%$$

where

$\overline{BFC_{ave}}(R_i)$ / $\overline{BFC_{ave}}(R_f)$ is the arithmetic mean of the average braking force coefficients in the initial/final braking test of the reference tyre within a test cycle.

(c) The temperature-corrected average braking force coefficients ($BFC_{ave,corr}$, see paragraph 3.2.1. of this Annex) as calculated from the initial and from the final braking tests of the reference tyre within a test cycle shall be not less than 0.57 and not greater than 0.79.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyres (T):

The coefficient of variation CV_{BFC} is calculated for each candidate tyre set. If one coefficient of variation is higher than 4 per cent, the data shall be discarded and the braking test repeated for that candidate tyre set.

4.1.6.3. Calculation of adjusted average braking force coefficient

The average braking force coefficient of the reference tyre set used for the calculation of its braking force coefficient is adjusted according to the positioning of each candidate tyre set in a given test cycle.

This adjusted average braking force coefficient of the reference tyre $BFC_{adj}(R)$ is calculated in accordance with Table 1 where $\overline{BFC_{ave}}(R_i)$ is the arithmetic mean of the average braking force coefficients in the initial braking test of the reference tyre set (R_i) and $\overline{BFC_{ave}}(R_f)$ is the arithmetic mean of the average braking force coefficients in the final braking test of the same reference tyre set (R_f) within the test cycle.

Table 1

If the number and the sequence of candidate tyre sets within one test cycle is:		and the candidate tyre set to be qualified within this test cycle is:	the corresponding adjusted average braking force coefficient of the reference tyre is calculated as follows:
1	$R_i - T_1 - R_f$	T_1	$BFC_{adj}(R) = 1/2 \bullet [\overline{BFC_{ave}}(R_i) + \overline{BFC_{ave}}(R_f)]$
2	$R_i - T_1 - T_2 - R_f$	T_1	$BFC_{adj}(R) = 2/3 \bullet \overline{BFC_{ave}}(R_i) + 1/3 \bullet \overline{BFC_{ave}}(R_f)$
		T_2	$BFC_{adj}(R) = 1/3 \bullet \overline{BFC_{ave}}(R_i) + 2/3 \bullet \overline{BFC_{ave}}(R_f)$
3	$R_i - T_1 - T_2 - T_3 - R_f$	T_1	$BFC_{adj}(R) = 3/4 \bullet \overline{BFC_{ave}}(R_i) + 1/4 \bullet \overline{BFC_{ave}}(R_f)$
		T_2	$BFC_{adj}(R) = 1/2 \bullet [\overline{BFC_{ave}}(R_i) + \overline{BFC_{ave}}(R_f)]$
		T_3	$BFC_{adj}(R) = 1/4 \bullet \overline{BFC_{ave}}(R_i) + 3/4 \bullet \overline{BFC_{ave}}(R_f)$

4.1.6.4. Calculation of the wet grip index of the candidate tyre

The wet grip index $G(T_n)$ of the candidate tyre T_n (n = 1, 2 or 3) is calculated as follows:

$$G(Tn) = K_{vehicle} \bullet \{\overline{BFC_{ave}}(Tn) - [a \bullet \Delta BFC(R) + b \bullet \Delta\vartheta + c \bullet (\Delta\vartheta)^2 + d \bullet \Delta MTD]\}$$

where:

$\overline{BFC_{ave}}(T_n)$ is the arithmetic mean of the average braking force coefficients of the candidate tyre T_n within a braking test;

$$\Delta BFC(R) = BFC_{adj}(R) - BFC(R_0)$$

$BFC_{adj}(R)$ is the adjusted average braking force coefficient in accordance with Table 1;

$BFC(R_0)$ = 0.68 is fixed as the braking force coefficient for the reference tyre in the reference conditions;

$$\Delta\vartheta = \vartheta - \vartheta_0$$

ϑ is the measured wet surface temperature in degrees Celsius when the candidate tyre T_n is tested;

ϑ_0 is the wetted surface reference temperature for the candidate tyre according to its category of use as listed in Table 2;

$$\Delta MTD = MTD - MTD_0$$

MTD = is the measured macro texture depth in mm of the track (see paragraph 3.1.4. of this Annex);

MTD_0 = 0.8 mm is the macro texture depth of the reference track;

$K_{vehicle}$ = 1.87 is a factor to grant consistency between previous calculation of the wet grip index and this one, and to ensure convergence between vehicle and trailer method and

coefficients *a*, *b*, *c* and *d* are given in Table 2.

Table 2

Category of use		ϑ_0 (°C)	a	b ($°C^{-1}$)	c ($°C^{-2}$)	d (mm^{-1})
Normal tyre		20	+0,99382	+0,00269	−0,00028	−0,02472
Snow tyre		15	+0,92654	−0,00121	−0,00007	−0,04279
	Snow tyre that is classified as tyre for use in severe snow conditions	10	+0,72029	−0,00539	+0,00022	−0,03037
Special use tyre		15	+0,92654	−0,00121	−0,00007	−0,04279
	Special use tyre that is classified as tyre for use in severe snow conditions	10	+0,72029	−0,00539	+0,00022	−0,03037

4.1.7. When a direct comparison between a candidate tyre and a reference tyre on the same vehicle is not possible the test method using a trailer or a tyre test vehicle (paragraph 4.2. of this Annex) shall be used.

4.1.7.4. Replacement of reference tyres

When irregular wear or damage results from tests, or when wear or aging influences the test results, the use of the reference tyre shall be discontinued.

4.2. Testing method (b) using a trailer towed by a vehicle or a tyre test vehicle

4.2.1. Principle

The measurements are conducted on test tyres mounted on a trailer towed by a vehicle (hereafter referred to as tow vehicle) or on a tyre test vehicle. The brake in the test position is applied firmly until sufficient braking torque is generated to produce the maximum braking force that will occur prior to wheel lockup at a test speed of 65 km/h.

4.2.2. Equipment

4.2.2.1. Tow vehicle and trailer or tyre test vehicle

The tow vehicle or the tyre test vehicle shall have the capability of maintaining the specified speed of (65 ± 2) km/h even under the maximum braking forces.

The trailer or the tyre test vehicle shall be equipped with one place where the tyre can be fitted for measurement purposes, hereinafter called "test position", and the following accessories:

(a) Equipment to activate brakes in the test position;

(b) A water tank to store sufficient water to supply the road surface wetting system, unless external watering is used;

(c) Recording equipment to record signals from transducers installed at the test position and to monitor water application rate if the self-watering option is used.

In the case of the one axle trailer, in order to reduce "pitch disturbance", the longitudinal distance from the centre line of the articulation point of the coupling to the transverse centre line of the axle of the trailer shall be at least ten times the "hitch height" or the "coupling (hitch) height".

In order to reduce "lateral disturbance", the trailer or the tyre test vehicle should be technically designed to minimize lateral displacement during the application of maximum braking force. Visual lateral displacement should be avoided during braking manoeuvre.

The maximum variation of toe-settings and camber angle for the test position shall be within ±0.5° with maximum vertical load. Suspension arms and bushings shall have sufficient rigidity necessary to minimize free play and ensure compliance under application of maximum braking forces. The suspension system shall provide adequate load-carrying capacity and be of such a design as to isolate suspension resonance.

The test position shall be equipped with a typical or special automotive brake system which can apply sufficient braking torque to produce the maximum value of braking test wheel longitudinal force at the conditions specified.

The brake application system shall be able to control the time interval between initial brake application and peak longitudinal force as specified in paragraph 4.2.7.1. below.

The trailer or the tyre test vehicle shall be designed to accommodate the range of candidate tyre sizes to be tested.

The trailer or the tyre test vehicle shall have provisions for adjustment of vertical load as specified in paragraph 4.2.5.2. below.

4.2.2.2. Measuring equipment

The test wheel position on the trailer or the tyre test vehicle shall be equipped with a rotational wheel velocity measuring system and with transducers to measure the braking force and vertical load at the test wheel.

General requirements for measurement system: The instrumentation system shall conform to the following overall requirements at ambient temperatures between 0 °C and 45 °C:

(a) The minimum frequency response shall be flat from 0 Hz to 100 Hz within ±1 per cent full scale;

(b) Overall system accuracy, speed: ±1.5 per cent of speed or ±1.0 km/h, whichever is greater.

Vehicle speed: To measure vehicle speed, a fifth wheel or non-contact precision speed-measuring system should be used.

Braking forces: The braking force-measuring transducers shall measure longitudinal force generated at the tyre–road interface as a result of brake application within a range from 0 per cent to at least 125 per cent of the applied vertical load. The transducer design and location shall minimize inertial effects and vibration-induced mechanical resonance.

Vertical load: The vertical load-measuring transducer shall measure the vertical load at the test position during brake application. The transducer shall have the same specifications as described previously.

Signal conditioning and recording system: All signal conditioning and recording equipment shall provide linear output with necessary gain and data reading resolution to meet the specified previous requirements. In addition, the following requirements apply:

(a) The minimum frequency response shall be flat from 0 Hz to 50 Hz (100 Hz) within ±1 per cent full scale;

(b) The signal-to-noise ratio shall be at least 20/1;

(c) The gain shall be sufficient to permit full-scale display for full-scale input signal level;

(d) The input impedance shall be at least ten times larger than the output impedance of the signal source;

(e) The equipment shall be insensitive to vibrations, acceleration, and changes in ambient temperature.

4.2.3. Conditioning of the test track

The test track should be conditioned by conducting at least ten test runs with tyres not involved in the test program at (65 ± 2) km/h.

4.2.4. Wetting conditions

The surface may be wetted from the track-side ("external watering") or by a wetting system incorporated in the test vehicle or the trailer ("self-watering").

4.2.4.1. If "external watering" is used, the test track surface shall be watered at least for half an hour prior to testing in order to equalize the surface temperature and water temperature. External watering should be supplied continuously throughout testing. For the braking lanes used, the water depth shall be between 0.5 mm and 1.5 mm, measured from the peak of the pavement.

4.2.4.2. For "self-watering" systems, the tow vehicle and trailer or the tyre test vehicle may be optionally equipped with a pavement-wetting system, less the storage tank, which, in the case of the trailer, is mounted on the tow vehicle. The water being applied to the pavement ahead of the test tyres shall be supplied by a nozzle suitably designed to ensure that the water layer encountered by the test tyre has a uniform cross section at the test speed with a minimum splash and overspray.

The nozzle configuration and position shall ensure that the water jets are directed towards the test tyre and pointed towards the pavement at an angle of 20° to 30°.

The water shall strike the pavement 250 mm to 450 mm ahead of the centre of tyre contact. The nozzle shall be located 25 mm above the pavement or at the minimum height required to clear obstacles which the tester is expected to encounter, but in no case more than 100 mm above the pavement.

The water layer shall be at least 25 mm wider than the test tyre tread and applied so the tyre is centrally located between the edges. Water delivery rate shall ensure a water depth of (1.0 ± 0.5) mm and shall be consistent throughout the test to within ±10 per cent. The volume of water per unit of wetted width shall be directly proportional to the test speed. The quantity of water applied at 65 km/h shall be 18 l/s per metre of width of wetted surface in case of a water depth of 1.0 mm.

4.2.5. Tyres and rims

4.2.5.1. Tyre preparation and stabilization and rims

The test tyres shall be trimmed to remove all protuberances on the tread surface caused by mould air vents or flashes at mould junctions.

The test tyre shall be mounted on a rim specified by a recognized tyre and rim standards organization as listed in Appendix 4 to Annex 6 to this Regulation. The rim width code shall not differ by more than 0.5 from the measuring rim width code.

A proper bead seat should be achieved by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

The tyres should be stabilized in performance prior to testing, which means that no evolution of the μ_{peak} value in test runs should be detectable; in any case there will be an ex-post verification according to paragraph 4.2.8.2. of this Annex. In all cases, tyre designed tread depth and designed tread block or rib integrity shall not change significantly with break-in, which means the pace and "severity" of the break-in needs to be carefully controlled to avoid such changes.

The test tyres/rim assemblies shall be stored in a location for a minimum of two hours such that they all have the same ambient temperature prior to testing. They should be shielded from the sun to avoid excessive heating by solar radiation.

4.2.5.2. Tyre load

The test load on the test tyre is (75 ± 5) per cent of the tyre load capacity.

4.2.5.3. Tyre inflation pressure

The test tyre cold inflation pressure shall be 180 kPa for standard-load tyres. For extra-load tyres, the cold inflation pressure shall be 220 kPa.

The tyre pressure should be checked just prior to testing at ambient temperature and adjusted if required.

4.2.6. Preparation of the tow vehicle and trailer or the tyre test vehicle

4.2.6.1. The test tyre set shall be installed on the measuring device and loaded to the specified test load according to paragraph 4.2.5.2. of this Annex.

For one-axle trailers, the hitch height and transverse position shall be adjusted in order to avoid any disturbance of the measuring results.

4.2.6.2. Instrumentation and equipment

Install the fifth wheel, when used, in accordance with the manufacturer's specifications and locate it as near as possible to the mid-track position of the tow trailer or the tyre test vehicle.

4.2.7. Procedure

4.2.7.1. Test run

The following procedure applies for each test run:

4.2.7.1.1. The tow vehicle or the tyre test vehicle is driven onto the test track in a straight line at the specified test speed (65 ± 2) km/h.

4.2.7.1.2. The recording system is launched.

4.2.7.1.3. For self-watering system, water shall be delivered to the pavement ahead of the test tyre approximately 0.5 s prior to brake application.

4.2.7.1.4. The brakes shall be activated within an area of six (6) metres in the longitudinal direction and 0.5 metres in the transversal direction of a measurement point of the wetted frictional properties of the surface and sand depth in accordance with paragraphs 3.1.4. and 3.1.5. above. The test shall be run in the same direction as in paragraph 3.2.2. of this Annex. The rate of braking application shall be such that the time interval between initial application of force and peak longitudinal force is in the range 0.2 s to 0.5 s.

4.2.7.1.5. The recording system is stopped.

4.2.7.2. Test cycle

Within the same test cycle, each test run of each braking test shall be made in the same direction and in accordance with paragraph 4.2.7.1. of this Annex. Several test cycles may be performed consecutively, where the final braking test of the reference tyre set of a test cycle may serve as the initial braking test of the reference tyre set for the next test cycle.

Up to three candidate tyre sets may be measured within the same test cycle, provided that the tests are completed within one day.

4.2.7.2.1. Initial braking test of the reference tyre set (R_i): first, the reference tyre set is mounted and at least six (6) valid test runs shall be made in accordance with paragraph 4.2.7.1. above.

4.2.7.2.2. Braking test of a candidate tyre set (T_n): the reference tyre set is replaced by a candidate tyre set and at least six (6) valid test runs with the candidate tyre set shall be performed.

4.2.7.2.3. After the braking test of the first candidate tyre set, up to two more candidate tyre sets may be measured.

4.2.7.2.4. Final braking test of the reference tyre set (R_f): the test cycle shall be closed by at least six (6) more valid test runs of the same reference tyre set as at the beginning of the test cycle.

Examples:

(a) The run order for a test cycle with three candidate tyre sets (T_1 to T_3) would be the following:
$R_i - T_1 - T_2 - T_3 - R_f$

(b) The run order for a braking test (consisting of two test cycles) of five candidate tyre sets (T_1 to T_5) would be the following:
$R_i - T_1 - T_2 - T_3 - R_f / R_i - T_4 - T_5 - R_f$.

4.2.8. Processing of measurement results

4.2.8.1. Calculation of the peak braking force coefficient

For each test run, the peak braking force coefficient (μ_{peak}) is the highest value of $\mu(t)$ before lockup occurs calculated as follows for each test run. Analogue signals should be filtered to remove noise. Digitally recorded signals must be filtered using a moving average technique.

$$\mu(t) = \left| \frac{f_h(t)}{f_v(t)} \right|$$

where:

$\mu(t)$ is the dynamic tyre braking force coefficient in real time;

$f_h(t)$ is the dynamic braking force in real time, in N;

$f_v(t)$ is the dynamic vertical load in real time, in N.

4.2.8.2. Validation of results

The μ_{peak} coefficient of variation CV_{μ} is calculated as follows:

$$CV_{\mu} = 100\% \bullet \frac{\sigma_{\mu}}{\overline{\mu_{peak}}}$$

where

$\sigma_{\mu} = \sqrt{\frac{1}{N-1}\Sigma_{j=1}^{N}(\mu_{peak,j} - \overline{\mu_{peak}})^2}$ denotes the corrected sample standard deviation and

$\overline{\mu_{peak}}$ the arithmetic mean of the peak braking force coefficients ($\mu_{peak,j}$) of N test runs.

For the reference tyre (R):

(a) The coefficients of variation CV_{μ} of the initial and the final braking tests of the reference tyre within one test cycle shall be less than or equal to 4 per cent;

(b) The arithmetic mean of the peak braking force coefficients of initial and the final braking test of the reference tyre within one test cycle shall not differ by more than 5 per cent of the average of the two values:

$$CVal(\mu_{peak}) = 100\% \bullet 2 \bullet \left| \frac{\overline{\mu_{peak}}(R_i) - \overline{\mu_{peak}}(R_f)}{\overline{\mu_{peak}}(R_i) + \overline{\mu_{peak}}(R_f)} \right| \leq 5\ \%$$

where

$\overline{\mu_{peak}}(R_i)$ and $\overline{\mu_{peak}}(R_f)$ are the arithmetic means of the peak braking force coefficients respectively in the initial and final braking tests of the reference tyre within a test cycle;

(c) The temperature-corrected average peak braking force coefficients ($\mu_{peak,corr}$, see paragraph 3.2.2. of this Annex) as calculated from the initial and from the final braking test of the reference tyre within a test cycle shall be not less than 0.65 and not greater than 0.90.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyre(s) (T_n):

The coefficient of variation of the peak braking force coefficient CV_{μ} is calculated for each candidate tyre. If one coefficient of variation is greater than 4 per cent, the data shall be discarded and the braking test repeated for this candidate tyre

4.2.8.3. Calculation of the adjusted average peak braking force coefficient of the reference tyre

The average peak braking force coefficient of the reference tyre used for the calculation of its braking force coefficient is adjusted according to the positioning of each candidate tyre in a given test cycle.

This adjusted average peak braking force coefficient of the reference tyre $\mu_{peak,adj}(R)$ is calculated in accordance with Table 3 where $\overline{\mu_{peak}}(R_i)$ is the arithmetic mean of the peak braking force coefficients in the initial test of the reference tyre (R_i) and $\overline{\mu_{peak}}(R_f)$ is the arithmetic mean of the peak braking force coefficients in the final test of the same reference tyre (R_f) within one test cycle.

Table 3

If the number and the sequence of candidate tyre sets within one test cycle is:		and the candidate tyre set to be qualified within this test cycle is:	the corresponding adjusted peak braking force coefficients of the reference tyre is calculated as follows:
1	$R_i - T_1 - R_f$	T_1	$\mu_{peak,adj}(R) = 1/2 \bullet [\overline{\mu_{peak}}(R_i) + \overline{\mu_{peak}}(R_f)]$
2	$R_i - T_1 - T_2 - R_f$	T_1	$\mu_{peak,adj}(R) = 2/3 \bullet \overline{\mu_{peak}}(R_i) + 1/3 \bullet \overline{\mu_{peak}}(R_f)$
		T_2	$\mu_{peak,adj}(R) = 1/3 \bullet \overline{\mu_{peak}}(R_i) + 2/3 \bullet \overline{\mu_{peak}}(R_f)$
3	$R_i - T_1 - T_2 - T_3 - R_f$	T_1	$\mu_{peak,adj}(R) = 3/4 \bullet \overline{\mu_{peak}}(R_i) + 1/4 \bullet \overline{\mu_{peak}}(R_f)$
		T_2	$\mu_{peak,adj}(R) = 1/2 \bullet [\overline{\mu_{peak}}(R_i) + \overline{\mu_{peak}}(R_f)]$
		T_3	$\mu_{peak,adj}(R) = 1/4 \bullet \overline{\mu_{peak}}(R_i) + 3/4 \bullet \overline{\mu_{peak}}(R_f)$

4.2.8.4. Calculation of the wet grip index of the candidate tyre

The wet grip index $G(T_n)$ of the candidate tyre T_n (n = 1, 2, 3) is calculated as follows:

$$G(T_n) = K_{trailer} \bullet \{\overline{\mu_{peak}}(T_n) - [a \bullet \Delta\mu_{peak}(R) + b \bullet \Delta\vartheta + c \bullet (\Delta\vartheta)^2 + d \bullet \Delta MTD]\}$$

where:

$\overline{\mu_{peak}}(T_n)$ is the arithmetic mean of the peak braking force coefficients of the candidate tyre T_n within a braking test;

$$\Delta\mu_{peak}(R) = \mu_{peak,adj}(R) - \mu_{peak}(R_0)$$

$\mu_{peak,adj}(R)$ is the adjusted peak braking force coefficient in accordance with Table 3;

$\mu_{peak}(R_0)$ = 0.85 is fixed as the peak braking force coefficient for the reference tyre in the reference conditions;

$$\Delta\vartheta = \vartheta - \vartheta_0$$

ϑ is the measured wet surface temperature in degrees Celsius when the candidate tyre T_n is tested;

ϑ_0 is the wetted surface reference temperature for the candidate tyre according to its sidewall marking as listed in Table 4;

$$\Delta MTD = MTD - MTD_0$$

MTD is the measured macro texture depth of the track

MTD_0 = 0.8 mm is fixed as the macro texture depth of the reference track;

$K_{trailer}$ = 1.50 is a factor to grant consistency between previous calculation of the wet grip index and this one, and to ensure convergence between vehicle and trailer method and

coefficient *a*, *b*, *c* and *d* are given in Table 4.

Table 4

Category of use		ϑ_0 (°C)	a	b ($°C^{-1}$)	c ($°C^{-2}$)	d (mm^{-1})
Normal tyre		20	+0,99757	+0,00251	– 0,00028	+0,07759
Snow tyre		15	+0,87084	– 0,00025	+0,00004	– 0,01635
	Snow tyre that is classified as tyre for use in severe snow conditions	10	+0,67929	+0,00115	– 0,00005	+0,03963
Special use tyre		15	+0,87084	– 0,00025	+0,00004	– 0,01635
	Special use tyre that is classified as tyre for use in severe snow conditions	10	+0,67929	+0,00115	– 0,00005	+0,03963

(B) – Classes C2 and C3 tyres

1. General test conditions

1.1. Track characteristics

The surface shall be a dense asphalt surface with a uniform gradient of not more than two per cent and shall not deviate more than 6 mm when tested with a 3 m straight edge.

The test surface shall have a pavement of uniform age, composition, and wear. The test surface shall be free of loose material or foreign deposits.

The maximum chipping size shall be from 8 mm to 13 mm.

The average macro texture depth measured as specified in ASTM E 965-96 (reapproved 2006) shall be (0.7 ± 0.3) mm.

1.1.1. The surface friction value for the wetted track shall be established by one or other of the following methods according to the class of the candidate tyre and the method (trailer or vehicle).

Tyre class	SRTT	Trailer method μ_{peak} range	Vehicle method BFC range
C2, C3	SRTT16	0.65 – 0.90	-
C2	SRTT16C	0.44 – 0.77	0.36 – 0.69
C3	SRTT19.5, SRTT22.5	0.51 – 0.67	0.35 – 0.61
C3	SRTT19.5 siped, SRTT22.5 siped	0.52 – 0.68	0.36 – 0.62

1.1.1.1. Standard Reference Test Tyre method using SRTT16

Using the method described in paragraph 4.2. of part (A) of this Annex, perform, in the same area where the average macro texture depth was measured, one braking test of the reference tyre, consisting of at least six (6) valid test runs in the same direction.

Evaluate the braking test as described in paragraphs 4.2.8.1. and 4.2.8.2. of part (A) of this Annex. If the coefficient of variation CV_{μ} exceeds 4 per cent, dismiss the results and repeat the braking test.

The arithmetic mean ($\overline{\mu_{peak}}$) of the measured peak braking force coefficients shall be corrected for the effects of temperature as follows:

$$\mu_{peak,corr} = \overline{\mu_{peak}} + a \bullet (\vartheta - \vartheta_0)$$

where

ϑ is the wetted track surface temperature in degrees Celsius,

$a = \ 0.002\ °C^{-1}$ and $\vartheta_0 = 20\ °C$.

The temperature corrected average peak braking force coefficient ($\mu_{peak,corr}$) shall be not less than 0.65 and not greater than 0.90.

The test shall be conducted using the lanes and length of the track to be used for the wet adhesion measurement.

For the trailer method, testing is run in such a way that braking occurs within 10 metres distance of where the surface was characterized.

1.1.1.2. Standard Reference Test Tyre method using SRTT16C, SRTT19.5, SRTT22.5, SRTT19.5 siped, SRTT22.5 siped;

1.1.1.2.1. Using the method described in paragraph 2.1. of Part (B) of this Annex, perform, in the same area where the average macro texture depth was measured, one braking test of the reference tyre, consisting of at least eight (8) valid test runs in the same direction in the same test session.

Evaluate the braking test as described in paragraphs 2.1.2.12. and 2.1.2.13. of part (B) of this Annex. If the coefficient of variation CV_{μ} exceeds 5 per cent, dismiss the results and repeat the braking test.

No temperature correction is applied.

The average peak braking force coefficient ($\overline{\mu_{peak}}$) shall be within the range reported in the table in paragraph 1.1.1.

The test shall be conducted using the lanes and length of the track to be used for the wet adhesion measurement.

1.1.1.2.2. Using the method described in paragraph 2.2. of Part (B) of this Annex, perform, in the same area where the average macro texture depth was measured, one braking test of the reference tyre, consisting of at least six (6) valid test runs in the same direction in the same test session.

Evaluate the braking test as described in paragraphs 2.2.2.7.1., 2.2.2.7.2. and 2.2.2.7.4. of part (B) of this Annex. If the coefficient of variation CV_{BFC} exceeds 3 per cent, dismiss the results and repeat the braking test.

No temperature correction is applied.

The braking force coefficient ($\overline{BFC}$) shall be within the range reported in the table in paragraph 1.1.1.

The test shall be conducted using the lanes and length of the track to be used for the wet adhesion measurement.

1.2. The surface may be wetted from the track-side or by a wetting system incorporated into the test vehicle or the trailer.

If a track-side system is used, the test surface shall be wetted for at least half an hour prior to testing in order to equalize the surface temperature and water temperature. It is recommended that track-side wetting be continuously applied throughout testing.

The water depth shall be between 0.5 and 2.0 mm.

1.3. The wind conditions shall not interfere with wetting of the surface (wind-shields are permitted).

The ambient and the wetted surface temperature shall be between 5 °C and 35 °C and shall not vary during the test by more than 10 °C.

1.4. In order to cover the range of the tyre sizes fitting the commercial vehicles, the Standard Reference Test Tyres (SRTT) shall be used to measure the relative wet index as shown in the following table:

For class C3 tyres
SRTT19.5, SRTT22.5, SRTT19.5 siped or SRTT22.5 siped
For class C2 tyres
SRTT16C

2. Test procedure

The comparative wet adhesion level shall be established using either:

(a) A trailer or special purpose tyre evaluation vehicle; or

(b) A standard production vehicle (M_2, M_3, N_1, N_2 or N_3, category) as defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.).

2.1. Trailer or special purpose tyre evaluation vehicle procedure

2.1.1. The measurements are conducted on (a) tyre(s) mounted on a trailer towed by a vehicle or a tyre test vehicle.

The brake on the test position is applied firmly until sufficient braking torque results to produce maximum braking force that will occur prior to wheel lockup at a test speed of 50 km/h. The trailer, together with the towing vehicle, or the tyre evaluation vehicle shall comply with the following requirements:

2.1.1.1. Be capable of exceeding the upper limit for the test speed of 50 km/h and of maintaining the test speed requirement of (50 ± 2) km/h even at the maximum level of application of braking forces;

2.1.1.2. Be equipped with an axle providing one test position having an hydraulic brake and actuation system that can be operated at the test position from the towing vehicle if applicable. The braking system shall be capable of providing sufficient braking torque to achieve the peak brake force coefficient over the range of tyre sizes and tyre loads to be tested;

2.1.1.3. Be capable of maintaining longitudinal alignment (toe) and camber of the test wheel and tyre assembly throughout the test within ±0.5° of the static figures achieved at the test tyre loaded condition;

2.1.1.4. In the case a track wetting system is incorporated:

The system shall be able to deliver the water such that the tyre and track surface in front of the tyre are wetted before the start of braking and throughout the duration of the test. The apparatus may be optionally equipped with a pavement-wetting system, less the storage tank, which, in the case of the trailer, is mounted on the tow vehicle. The water being applied to the pavement ahead of the test tyres shall be supplied by a nozzle suitably designed to ensure that the water layer encountered by the test tyre has a uniform cross section at the test speed with a minimum splash and overspray.

The nozzle configuration and position shall ensure that the water jets shall be directed toward the test tyre and pointed toward the pavement at an angle of 15 to 30°. The water shall strike the pavement 0.25 to 0.5 m ahead of the centre of tyre contact. The nozzle shall be located 100 mm above the pavement or the minimum height required to clear obstacles which the tester is expected to encounter, but in no case more than 200 mm above the pavement. The water layer shall be at least 25 mm wider than the test tyre tread and applied so the tyre is centrally located between the edges. The volume of water per unit of wetted width shall be directly proportional to the test speed. The quantity of water applied at 50 km/h shall be 14 l/s per metre of the width of the wetted surface. The nominal values of rate of water application shall be maintained within ±10 per cent.

2.1.2. Test procedure

2.1.2.1. Fit the test tyres on rims specified by a recognized tyre and rim standards organization as listed in Appendix 4 to Annex 6 to this Regulation. Ensure proper bead seating by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

Check the test tyres for the specified inflation pressure at ambient temperature (cold), just prior to testing. For the purpose of this standard the testing tyre cold inflation pressure P_t shall be calculated as follows:

$$P_t = P_r \bullet \left(\frac{Q_t}{Q_r}\right)^{1.25}$$

Where:

P_r = Inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

Q_t = The static test load of the tyre

Q_r = The maximum mass associated with the load capacity index of the tyre

2.1.2.2. For tyre break-in, two braking runs are performed. The tyre shall be conditioned for a minimum of two hours adjacent to the test track such that it is stabilized at the ambient temperature of the test track area. The tyre(s) shall not be exposed to direct sunshine during conditioning.

2.1.2.3. The load conditions for testing shall be 75 ± 5 per cent of the value corresponding to the load index.

2.1.2.4. Shortly before testing, the track shall be conditioned by carrying out at least ten braking test runs at 50 km/h on the part of the track to be used for the performance test programme but using a tyre not involved in that programme;

2.1.2.5. Immediately prior to testing, the tyre inflation pressure shall be checked and reset, if necessary, to the values given in paragraph 2.1.2.1.

2.1.2.6. The test speed shall be at 50 ± 2 km/h and shall be maintained between these limits throughout the test run.

2.1.2.7. The direction of the test shall be the same for each set of tests and shall be the same for the test tyre as that used for the SRTT with which its performance is to be compared.

2.1.2.8. Deliver water to the pavement ahead of the test tyre approximately 0.5 s prior to brake application (for self-watering system). The brakes of the test wheel assembly shall be applied such that peak braking force is achieved within 0.2 s and 1.0 s of brake application.

2.1.2.9. For new tyres, the first two braking runs are discarded for tyre break-in.

2.1.2.10. For the evaluation of the performance of any tyre compared with that of the SRTT, the braking tests should be run at the same area on the test track.

2.1.2.11. The order of testing shall be:

R1 - T - R2

Where:

R1 = the initial test of the SRTT,

R2 = the repeat test of the SRTT and

T = the test of the candidate tyre to be evaluated.

A maximum of three candidate tyres may be tested before repeating the SRTT test, for example:

R1 - T1 - T2 - T3 - R2

2.1.2.12. Calculate the peak braking force coefficient, μ_{peak}, for each test using the following equation:

$$\mu(t) = \left| \frac{f_h(t)}{f_v(t)} \right| \quad (1)$$

Where:

$\mu(t)$ = dynamic tyre braking force coefficient in real time,

$f_h(t)$ = dynamic braking force in real time, N,

$f_v(t)$ = dynamic vertical load in real time, N

Using equation (1) for dynamic tyre braking force coefficient, calculate the peak tyre braking force coefficient, μ_{peak}, by determining the highest value of $\mu(t)$ before lockup occurs. Analogue signals should be filtered to remove noise. Digitally recorded signals may be filtered using a moving average technique.

Calculate the average values of peak braking force coefficient ($\mu_{peak,\ ave}$) by averaging four or more valid repeated runs for each set of test and reference tyres for each test condition provided that the tests are completed within the same day.

2.1.2.13. Validation of results

For the reference tyre:

(a) If the coefficient of variation of the peak braking coefficient CV_μ of the reference tyre, which is calculated by the formula given in 4.2.8.2. of part (A) of this Annex, is higher than five per cent, discard all data and repeat the test for this reference tyre.

(b) The average peak braking force coefficients ($\overline{\mu_{peak}}$, see paragraph 1.1.1.2.1. of this Annex) as calculated from the initial and from the final braking test of the reference tyre within a test cycle shall be within the range reported in the table in paragraph 1.1.1.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyres:

The coefficients of variation CV_{μ} are calculated for all the candidate tyres according to the formula in 4.2.8.2. of part (A) of this Annex. If one coefficient of variation is greater than five per cent, discard the data for this candidate tyre and repeat the test.

If R_1 is the average of the peak braking coefficient in the first test of the reference tyre, R_2 is the average of the peak braking coefficient in the second test of the reference tyre, the following operations are performed, according to the following table:

If the number of sets of candidate tyres between two successive runs of the reference tyre is:	and the set of candidate tyres to be qualified is:	then "Ra" is calculated by applying the following:
1 R1 – T1 – R2	T1	$Ra = 1/2 (R_1 + R_2)$
2 R1 – T1 - T2 – R2	T1	$Ra = 2/3 R_1 + 1/3 R_2$
	T2	$Ra = 1/3 R_1 + 2/3 R_2$
3 R1 – T1 - T2 - T3 – R2	T1	$Ra = 3/4 R_1 + 1/4 R_2$
	T2	$Ra = 1/2 (R_1 + R_2)$
	T3	$Ra = 1/4 R_1 + 3/4 R_2$

2.1.2.14. The wet grip index (G) shall be calculated as:

$$\text{Wet grip index } (G) = f \bullet \frac{\mu_{peak\ ave}(T)}{\mu_{peak\ ave}(R)}$$

where

For class C2 tyres	
SRTT16C	
$f = 1$	
For class C3 tyres	
SRTT19.5, SRTT22.5	*SRTT19.5 siped, SRTT22.5 siped*
$f = 1$	$f = 1.02$

f: correction factor depending on used SRTT

It represents the relative wet grip index for braking performance of the candidate tyre (T) compared to the reference tyre (R).

2.2. Standard vehicle procedure

2.2.1. The vehicle used shall have two axles and be equipped with an anti-lock braking system (e.g. standard production vehicle of M_2, M_3, N_1, N_2 or N_3 category). The ABS shall continue to fulfil the utilisation of adhesion requirements defined in the Regulations as appropriate, and shall be comparable and constant throughout the tests with the different tyres mounted.

2.2.1.1. Measuring equipment

The vehicle shall be fitted with a sensor suitable for measuring speed on a wet surface and distance covered between two speeds.

To measure vehicle speed, a fifth wheel or non-contact speed-measuring system shall be used.

The following tolerances shall be respected:

(a) For the speed measurements: ±1 per cent or ±0.5 km/h whichever is greater;

(b) For the distance measurements: $\pm 1 \times 10^{-1}$ m.

A display of the measured speed or the difference between the measured speed and the reference speed for the test can be used inside the vehicle so that the driver can adjust the speed of the vehicle.

A data acquisition system can be also used for storing the measurements.

2.2.2. Test procedure

Starting with a defined initial speed, the brakes are applied hard enough on the two axles at the same time to activate the ABS system.

2.2.2.1. The Average Deceleration (AD) is calculated between two defined speeds, with an initial speed of 60 km/h and a final speed of 20 km/h.

2.2.2.2. Vehicle equipment

The rear axle may be indifferently fitted with 2 or 4 tyres.

For the reference tyre testing, both axles are fitted with reference tyres. (A total of 4 or 6 reference tyres depending on the choice above mentioned).

For the candidate tyre testing, 3 fitting configurations are possible:

(a) "Configuration 1": candidate tyres on front and rear axles: it is the standard configuration that should be used every time it is possible.

(b) "Configuration 2": candidate on front axle and reference tyre or control tyre on rear axle: allowed in such cases where fitting the candidate tyre on the rear position is not possible.

(c) "Configuration 3": candidate on rear axle and reference tyre or control tyre on front axle: permitted in such cases where fitting the candidate tyre on the front position is not possible.

2.2.2.3. Tyre inflation pressure

(a) For a vertical load higher or equal to 75 per cent of the load capacity of the tyre, the test inflation pressure "P_t" shall be calculated as follows:

$P_t = P_r \cdot (Q_t/Q_r)^{1.25}$

P_r = Inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

Q_t = static test load of the tyre

Q_r = maximum mass associated with the load capacity index of the tyre

(a) For a vertical load lower than 75 per cent of the load capacity of the tire, the test inflation pressure P_t shall be calculated as follows:

$P_t = P_r \cdot (0.75)^{1.25} = (0.7) \cdot P_r$

P_r = Inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

Check the tyre pressure just prior to testing at ambient temperature.

2.2.2.4. Tyre load

The static load on each axle shall remain the same throughout the test procedure. The static load on each tyre, expressed as a percent of the nominal static load and rounded to the nearest integer, shall lie between 60 per cent and 100 per cent of the SRTT and the candidate tyre's load capacity.

Tyre load on the same axle should not differ by more than 10 per cent.

The use of fitting as per Configurations 2 and 3 shall fulfil the following additional requirements:

Configuration 2: Front axle load > Rear axle load

The rear axle may be indifferently fitted with 2 or 4 tyres

Configuration 3: Rear axle load > Front axle load x 1.8

2.2.2.5. Tyre preparation and break-in

2.2.2.5.1. The test tyre shall be mounted on the test rim declared by the tyre manufacturer.

Ensure proper bead seating by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

2.2.2.5.2. Place the fitted test tyres in a location for a minimum of two hours such that they all have the same ambient temperature prior to testing, and shield them from the sun to avoid excessive heating by solar radiation. For tyre break-in, perform two braking runs.

2.2.2.5.3. Condition the pavement by conducting at least ten test runs with tyres not involved in the test programme at an initial speed higher or equal to 65 km/h (which is higher than the initial test speed to guarantee that a sufficient length of track is conditioned).

2.2.2.6. Procedure

2.2.2.6.1. First, mount the set of reference tyres on the vehicle.

The vehicle accelerates in the starting zone up to (65 ± 2) km/h.

Activation of the brakes on the track is made always at the same place with a tolerance of 5 metres in longitudinal and 0.5 metres in transverse.

2.2.2.6.2. According to the type of transmission, two cases are possible:

(a) Manual transmission

As soon as the driver is in the measuring zone and having reached (65 ± 2) km/h, the clutch is released and the brake pedal depressed sharply, holding it down as long as necessary to perform the measurement.

(b) Automatic transmission

As soon as the driver is in the measuring zone and having reached (65 ± 2) km/h, select neutral gear and then the brake pedal is depressed sharply, holding it down as long as necessary to perform the measurement.

Automatic activation of the brakes can be performed by means of a detection system made of two parts, one indexed to the track and one embarked on the vehicle. In that case braking is made more rigorously at the same portion of the track.

If any of the above-mentioned conditions are not met when a measurement is made (speed tolerance, braking time, etc.), the measurement is discarded and a new measurement is made.

2.2.2.6.3. Test running order

Examples:

The run order for a test of 3 sets of candidate tyres (T1 to T3) plus a reference tyre R would be:

R - T1 - T2 - T3 - R

The run order for a test of 5 sets of tyres (T1 to T5) plus a reference tyre R would be:

R - T1 - T2 - T3 - R -T4 - T5 – R

2.2.2.6.4. The direction of the test shall be the same for each set of tests and shall be the same for the candidate test tyre as that used for the SRTT with which its performance is to be compared.

2.2.2.6.5. For each test and for new tires, the first two braking measurements are discarded.

2.2.2.6.6. After at least 3 valid measurements have been made in the same direction, the reference tyres are replaced by a set of the candidate tyres (one of the 3 configurations presented in paragraph 2.2.2.2.) and at least 6 valid measurements shall be performed.

2.2.2.6.7. A maximum of three sets of candidate tyres can be tested before the reference tyre is re-tested.

2.2.2.7. Processing of measurement results

2.2.2.7.1. Calculation of the Average Deceleration (AD)

Each time the measurement is repeated, the average deceleration AD [$m \cdot s^{-2}$] is calculated by:

$$AD = \left| \frac{S_f^{\,2} - S_i^{\,2}}{2d} \right|$$

Where d [m] is the distance covered between the initial speed S_i [$m \cdot s^{-1}$] and the final speed S_f [$m \cdot s^{-1}$].

2.2.2.7.2. Validation of results

For the reference tyre:

(a) If the coefficient of variation of "AD" of any two consecutive groups of 3 runs of the reference tyre is higher than 3 per cent, discard all data and repeat the test for all tyres (the candidate tyres and the reference tyre). The coefficient of variation is calculated by the following relation:

$$\frac{\text{standard deviation}}{\text{average}} \times 100$$

(b) The average braking force coefficients ($\overline{BFC}$, see paragraph 1.1.1.2.2. of this Annex) as calculated from the initial and from the final braking tests of the reference tyre within a test cycle shall be within the range reported in the table in paragraph 1.1.1.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyres:

The coefficients of variation are calculated for all the candidate tyres.

$$\frac{\text{standard deviation}}{\text{average}} \times 100$$

If one coefficient of variation is greater than 3 per cent, discard the data for this candidate tyre and repeat the test.

2.2.2.7.3. Calculation of the "average AD"

If R_1 is the average of the AD values in the first test of the reference tyre and R_2 is the average of the AD values in the second test of the reference tyre, the following operations are performed, according to Table 5.

Ra is the adjusted average AD of the reference tyre.

Table 5

Number of sets of candidate tyres between two successive runs of the reference tyre		Set of candidate tyres to be qualified	Ra
1	R1-T1-R2	T1	$Ra = 1/2 (R_1 + R_2)$
2	R1-T1-T2-R2	T1	$Ra = 2/3 R_1 + 1/3 R_2$
		T2	$Ra = 1/3 R_1 + 2/3 R_2$
3	R1-T1-T2-T3-R2	T1	$Ra = 3/4 R_1 + 1/4 R_2$
		T2	$Ra = 1/2 (R_1 + R_2)$
		T3	$Ra = 1/4 R_1 + 3/4 R_2$

2.2.2.7.4. Calculation of braking force coefficient, BFC

BFC(R) and BFC(T) are calculated according to Table 6:

Table 6

Tested tyre	Braking force coefficient is
Reference tyre	BFC(R) = Ra/g
Candidate tyre	BFC(T) = Ta/g
g is the acceleration due to gravity (rounded to 9.81 m s^{-2}).	

Ta (a = 1, 2, etc.) is the average of the AD values for a test of a candidate tyre.

2.2.2.7.5. Calculation of the relative wet grip index of the tyre

The wet grip index represents the relative performance of the candidate tyre compared to the reference tyre. The way to obtain it depends on the test configuration as defined in paragraph 2.2.2.2. of this Annex. The wet grip index *G* of the tyre is calculated as reported into Table 7:

Table 7

Configuration C1: candidate tyres on both axles	$G = f \bullet \frac{BFC(T)}{BFC(R)}$
Configuration C2: candidate tyres on front axle and reference tyres on rear axle	$G = f \bullet \frac{BFC(T) \bullet [a + b + h \bullet BFC(R)] - a \bullet BFC(R)}{BFC(R) \bullet [b + h \bullet BFC(T)]}$
Configuration C3: reference tyres on front axle and candidate tyres on rear axle	$G = f \bullet \frac{BFC(T) \bullet [-a - b + h \bullet BFC(R)] + b \bullet BFC(R)}{BFC(R) \bullet [-a + h \bullet BFC(T)]}$

where

For class C2 tyres *SRTT16C*	
$f = 1$	
For class C3 tyres	
SRTT19.5, SRTT22.5	*SRTT19.5 siped, SRTT22.5 siped*
$f = 1$	$f = 1.02$

Where (see also Figure 1):

f: correction factor depending on used SRTT

cog: centre of gravity of the loaded vehicle

m: mass (in kilograms) of the loaded vehicle

a: horizontal distance between front axle and centre of gravity of the loaded vehicle (m)

b: horizontal distance between rear axle and centre of gravity of the loaded vehicle

h: vertical distance between ground level and centre of gravity of the loaded vehicle (m).

N.B. When *h* is not precisely known, these worst case values shall apply: 1.2 for configuration C2, and 1.5 for configuration C3

□: loaded vehicle acceleration [m•s^{-2}]

g: acceleration due to the gravity [m•s^{-2}]

X_1: longitudinal (X-direction) reaction of the front tyre on the road

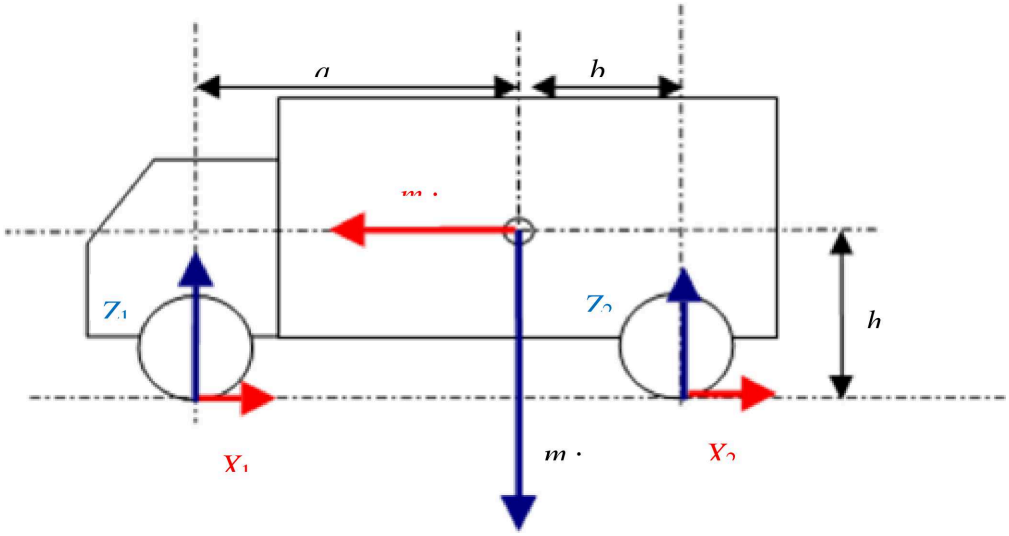
X_2: longitudinal (X-direction) reaction of the rear tyre on the road

Z_1: normal (Z-direction) reaction of the front tyre on the road

Z_2: normal (Z-direction) reaction of the rear tyre on the road

Figure 1

Nomenclature explanation related to grip index of the tyre



2.2.2.8. Wet adhesion comparison between a candidate tyre and a reference tyre using a control tyre

When the candidate tyre size is significantly different from the reference tyre, a direct comparison on the same vehicle may be not possible. This approach uses an intermediate tyre, hereinafter called the control tyre.

2.2.2.8.1. The principle lies upon the use of a control tyre and 2 different vehicles for assessing a candidate tyre in comparison with a reference tyre.

One vehicle can fit the reference tyre and the control tyre, the other the control tyre and the candidate tyre. All conditions are in conformity with paragraphs 2.2.1. to 2.2.2.5. above.

2.2.2.8.2. The first assessment is a comparison between the control tyre and the reference tyre. The result (Wet Grip Index 1) is the relative efficiency of the control tyre compared to the reference tyre.

2.2.2.8.3. The second assessment is a comparison between the candidate tyre and the control tyre. The result (Wet Grip Index 2) is the relative efficiency of the candidate tyre compared to the control tyre.

The second assessment is done on the same track as the first one and within one week maximum. The wetted surface temperature shall be in the range of +5°C of the temperature of the first assessment. The control tyre set (4 or 6 tyres) is physically the same set as the set used for the first assessment.

2.2.2.8.4. The wet grip index of the candidate tyre compared to the reference tyre is deduced by multiplying the relative efficiencies calculated above:

(Wet Grip Index 1 · Wet Grip Index 2)

Note: When the test expert decides to use an SRTT tyre as a control tyre (i.e. in the test procedure two SRTTs are compared directly instead of an SRTT with a control tyre) the result of the comparison between the SRTTs is called the "local shift factor".

It is permitted to use a previous SRTTs comparison.

The comparison results shall be checked periodically.

2.2.2.8.5. Selection of a set of tyres as a control tyre set

A "control tyre" set is a group of identical tyres made in the same factory during a one week period.

2.2.2.8.6. Reference and control tyres

Before the first assessment (control tyre / reference tyre), normal storage conditions can be used. It is necessary that all the tyres of a control tyre set have been stored in the same conditions.

2.2.2.8.7. Storage of control tyres

As soon as the control tyre set has been assessed in comparison with the reference tyre, specific storage conditions shall be applied for control tyres replacement.

2.2.2.8.8. Replacement of reference and control tyres

When irregular wear or damage results from tests, or when wear influencesthe test results, the use of the tyre shall be discontinued.

Annex 5 – Appendix

Test reports examples of wet grip index for tyres in new state

Example 1: Test report of wet grip index for tyres in new state using trailer or tyre test vehicle method

Test report number:		Test date:		
Track:			Minimum:	Maximum:
Texture depth (mm):		Wetted surface temp. (°C):		
$\mu_{peak,corr}$[(4)]:		Ambient temp (°C):		
Water depth (mm):				
Speed (km/h):				

No.		*1*	*2*	*3*	*4*	*5*
Brand						
Pattern/trade description		SRTT…				SRTT…
Size						
Service description						
Reference (test) inflation pressure[1] (kPa)						
Tyre identification						
M+S marking (Y/N)						
3PMSF marking (Y/N)						
Rim						
Load (kg)						
Pressure (kPa)						
μ_{peak}	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
$\overline{\mu_{peak}}$						
Standard deviation, σ_{μ}						
$CV_{\mu} \leq 4$ % [2]						
$CVal(\mu_{peak}) \leq 5$ % [3]						
$\mu_{peak,corr}(R)$						
$\mu_{peak,adj}(R)$						
f						
Wet grip index						
Wetted surface temp. (°C)						
Ambient temp. (°C)						
Remarks						

[1] for classes C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation

[2] For classes C2 and C3 tyres, the limit is 5 %.

[3] For classes C2 and C3 tyres, $CVal(\mu_{peak})$ is not defined nor applied.

[4] For classes C2 and C3 tyres, no temperature correction is applied when paragraph 1.1.1.2. is applied.

Example 2: Test report of wet grip index for tyres in new state using vehicle method

Test report number:		Test date:	

Track:			Minimum:	Maximum:	Vehicle		
Texture depth (mm):		Wetted surface temp. (°C):			Brand:		
$BFC_{ave,corr,1}$ [5]: or BFC_{ave} or $\mu_{peak,corr}$ [4]:		Ambient temp (°C):			Model:		
$BFC_{ave,corr,2}$ [5]:					Type:		
$CVal(BFC_{ave,corr})$:					Year of registration:		
Water depth (mm):					Maximum axle load:	Front	Rear

Initial speed (km/h):		Final speed (km/h):	

No.	*1*		*2*		*3*		*4*		*5*	
Brand										
Pattern/trade description	SRTT…								SRTT…	
Size										
Service description										
Reference (test) inflation pressure[1] (kPa)										
Tyre identification										
M+S marking (Y/N)										
3PMSF marking (Y/N)										
Rim										
Front axle pressure (kPa)	left:	right:	left:	right:	left:	right:	left:	right:	left:	right:

Rear axle pressure (kPa)		left:	right:	left:	right:	left:	right:	left:	right:	left:	right:
Front axle load (kg)		left:	right:	left:	right:	left:	right:	left:	right:	left:	right:
Rear axle load (kg)		left:	right:	left:	right:	left:	right:	left:	right:	left:	right:
		Braking distance (m)	BFC_i	*Braking distance (m)*	BFC_i	*Braking distance (m)*	BFC_i	*Braking distance (m)*	BFC_i	*Braking distance (m)*	BFC_i
Measurement	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
$\overline{BFC_{ave}}$											
Standard deviation, σ_{BFC}											
$CV_{BFC} \leq 4\ \%$ [2]											
$CVal(BFC_{ave}) \leq 5\ \%$ [3]											
$BFC_{ave,corr}(R)$											
$BFC_{adj}(R)$											
f											
Wet grip index											
Wetted surface temp. (°C)											
Ambient temp. (°C)											
Remarks											

[1] for classes C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

[2] For classes C2 and C3 tyres, the limit is 3 %.

[3] For classes C2 and C3 tyres, $CVal(BFC_{ave})$ is not defined nor applied.

[4] For classes C2 and C3 tyres, depending on whether paragraph 1.1.1.1 or 1.1.1.2. applies.

[5] For classes C2 and C3 tyres, $BFC_{ave,corr}$ is not defined nor applied

ANNEX 6

Test procedure for measuring rolling resistance

1. Test methods

The alternative measurement methods listed below are given in this Regulation. The choice of an individual method is left to the tester. For each method, the test measurements shall be converted to a force acting at the tyre/drum interface. The measured parameters are:

(a) In the force method: the reaction force measured or converted at the tyre spindle; ([1])

(b) In the torque method: the torque input measured at the test drum; ([2])

(c) In the deceleration method: the measurement of deceleration of the test drum and tyre assembly;[2]

(d) In the power method: the measurement of the power input to the test drum.[2]

2. Test equipment

2.1. Drum specifications

2.1.1. Diameter

The test dynamometer shall have a cylindrical flywheel (drum) with a diameter of at least 1.7 m.

The F_r and C_r values shall be expressed relative to a drum diameter of 2.0 m. If drum diameter different than 2.0 m is used, a correlation adjustment shall be made following the method in paragraph 6.3. of this Annex.

2.1.2. Surface

The surface of the drum shall be smooth steel. Alternatively, in order to improve skim test reading accuracy, a textured surface may also be used, which should be kept clean.

The F_r and C_r values shall be expressed relative to the "smooth" drum surface. If a textured drum surface is used, see Appendix 1, paragraph 7.

2.1.3. Width

The width of the drum test surface shall exceed the width of the test tyre contact patch.

2.2. Measuring rim

The tyre shall be mounted on a steel or light alloy measuring rim, as follows:

(a) For class C1 tyres, the width of the rim shall be as defined in ISO 4000-1:2021,

(b) For classes C2 and C3 tyres, the width of the rim shall be as defined in ISO 4209-1:2001.

In cases where the width is not defined in the above mentioned ISO Standards, the rim width as defined by one of the standards organizations as specified in Appendix 4 may be used.

([1]) This measured value also includes the bearing and aerodynamic losses of the wheel and tyre which are also to be considered for further data interpretation.

([2]) The measured value in the torque, deceleration and power methods also includes the bearing and aerodynamic losses of the wheel, the tyre, and the drum which are also to be considered for further data interpretation.

2.3. Load, alignment, control and instrumentation accuracies

Measurement of these parameters shall be sufficiently accurate and precise to provide the required test data. The specific and respective values are shown in Appendix 1.

2.4. Thermal environment

2.4.1. Reference conditions

The reference ambient temperature, measured at a distance not less than 0.15 m and not more than 1 m from the tyre sidewall, shall be 25 °C.

2.4.2. Alternative conditions

If the test ambient temperature is different from the reference ambient temperature, the rolling resistance measurement shall be corrected to the reference ambient temperature in accordance with paragraph 6.2. of this Annex.

3. Test conditions

3.1. General

The test consists of a measurement of rolling resistance in which the tyre is inflated to the required cold inflation pressure and the inflation pressure allowed to build up, i.e., "capped inflation".

3.2. Test speeds

The rolling resistance coefficient value shall be obtained at the appropriate drum speed specified in Table 1.

Table 1

Test Speeds (in km/h)

Tyre class	C1	C2 and C3	C3	
Load index	All	LI ≤ 121	LI > 121	
Speed category symbol	All	All	J (100 km/h) and lower	K (110 km/h) and higher
Test speed (km/h)	80	80	60	80

3.3. Test load

The standard test load shall be computed from the values shown in Table 2 and shall be kept within the tolerance specified in Appendix 1.

3.4. Test inflation pressure

The inflation pressure shall be in accordance with that shown in Table 2 and shall be capped with the accuracy specified in paragraph 4. of Appendix 1 to this annex.

Table 2

Test loads and inflation pressures

Tyre class	C1		C2, C3
	Standard load	Reinforced or extra load	
Load - % of maximum load capacity as indicated by the load capacity index	80	80	85 (Refer to single application)
Inflation pressure kPa	210	250	Test inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

Note: The inflation pressure shall be capped with the accuracy specified in paragraph 4. of Appendix 1 to this Annex.

3.5. Duration and speed.

When the deceleration method is selected, the following requirements apply:

(a) The deceleration j shall be determined in differential $d\omega/dt$ or discrete $\Delta\omega/\Delta t$ form, where ω is angular velocity, t – time;

If the differential form $d\omega/dt$ is used, then the recommendations of Appendix 5 to this annex are to be applied;

(b) For duration Δt, the time increments shall not exceed 0.5 s;

(c) Any variation of the test drum speed shall not exceed 1 km/h within one time increment.

4. Test procedure

4.1. General

The test procedure steps described below shall be followed in the sequence given.

4.2. Thermal conditioning

The inflated tyre shall be placed in the thermal environment of the test location for a minimum of:

(a) 3 hours for class C1 tyres;

(b) 6 hours for classes C2 and C3 tyres.

4.3. Pressure adjustment

After thermal conditioning, the inflation pressure shall be adjusted to the test pressure, and verified 10 minutes after the adjustment is made.

4.4. Warm-up

The warm-up durations shall be as specified in Table 3.

Table 3

Warm up durations

Tyre class	C1	C2 and C3 LI ≤ 121	C3 LI > 121	
Nominal rim diameter	All	All	< 22.5	≥ 22.5
Warm up duration	30 min.	50 min.	150 min.	180 min.

4.5. Measurement and recording

The following shall be measured and recorded (see Figure 1):

(a) Test speed U_n;

(b) Load on the tyre normal to the drum surface L_m;

(c) The initial test inflation pressure as defined in paragraph 3.3. above;

(d) The coefficient of rolling resistance measured C_r, and its corrected value C_{rc}, at 25 °C and for a drum diameter of 2 m;

(e) The distance from the tyre axis to the drum outer surface under steady state $r_{L,}$;

(f) Ambient temperature t_{amb};

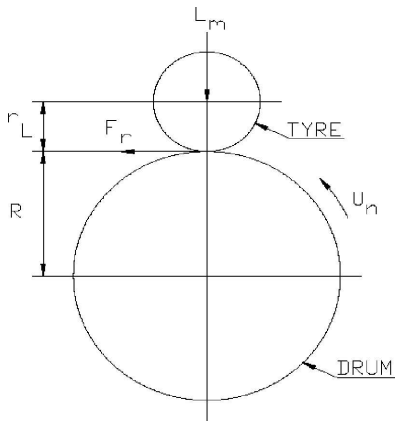
(g) Test drum radius R;

(h) Test method chosen;

(i) Test rim (size and material);

(j) Tyre size, manufacturer, type, identity number (if one exists), speed category symbol, load index, DOT number (Department of Transportation).

Figure 1



All the mechanical quantities (forces, torques) will be orientated in accordance with the axis systems specified in ISO 8855:2011.

The directional tyres shall be run in their specified rotation sense.

4.6. Measurement of parasitic losses

The parasitic losses shall be determined by one of the following procedures given in paragraph 4.6.1. or 4.6.2. below.

4.6.1. Skim test reading

Skim test reading follows the procedure below:

(a) Reduce the load to maintain the tyre at the test speed without slippage. ([3])
The load values should be as follows:

(i) Class C1 tyres: recommended value of 100 N; not to exceed 200 N;

(ii) Class C2 tyres: recommended value of 150 N; not to exceed 200 N for machines designed for class C1 tyre measurement or 500 N for machine designed for classes C2 and C3 tyres;

(iii) Class C3 tyres: recommended value of 400 N; not to exceed 500 N.

(b) Record the spindle force F_t, input torque T_t, or the power, whichever applies;[3]

(c) Record the load on the tyre normal to the drum surface L_m[3].

4.6.2. Deceleration method

The deceleration method follows the procedure below:

(a) Remove the tyre from the test surface while running at a speed greater than test speed;

(b) Record the deceleration of the test drum $\Delta\omega_{D0}/\Delta t$ and that of the unloaded tyre $\Delta\omega_{T0}/\Delta t$ or record the deceleration of the test drum j_{D0} and that of the unloaded tyre j_{T0} in exact or approximate form in accordance with paragraph 3.5. above.

The speed range for measurement is test speed ±10 km/h.

4.7. Allowance for machines exceeding σ_m criterion

The steps described in paragraphs 4.3. to 4.5. above shall be carried out once only, if the measurement standard deviation determined in accordance with paragraph 6.5. below is:

(a) Not greater than 0.075 N/kN for classes C1 and C2 tyres;

(b) Not greater than 0.06 N/kN for class C3 tyres.

If the measurement standard deviation exceeds this criterion, the measurement process will be repeated n times as described in paragraph 6.5. below. The rolling resistance value reported shall be the average of the n measurements.

5. Data interpretation

5.1. Determination of parasitic losses

5.1.1. General

The laboratory shall perform the measurements described in paragraph 4.6.1. above for the force, torque and power methods or those described in paragraph 4.6.2. above for the deceleration method, in order to determine precisely in the test conditions (load, speed, temperature) the tyre spindle friction, the tyre and wheel aerodynamic losses, the drum (and as appropriate, engine and/or clutch) bearing friction, and the drum aerodynamic losses.

([3]) With the exception of the force method, the measured value includes the bearing and aerodynamic losses of the wheel, the tyre, and the drum losses which also need to be considered.
It is known that the spindle and drum bearing frictions depend on the applied load. Consequently, it is different for the loaded system measurement and the skim test reading. However, for practical reasons, this difference can be disregarded.

The parasitic losses related to the tyre/drum interface F_{pl} expressed in newtons shall be calculated from the force F_t torque, power or the deceleration, as shown in paragraphs 5.1.2. to 5.1.5. below.

5.1.2. Force method at tyre spindle

Calculate: $F_{pl} = F_t (1 + r_L/R)$

Where:

F_t is the tyre spindle force in newtons (see paragraph 4.6.1. above),

r_L is the distance from the tyre axis to the drum outer surface under steady state conditions, in metres,

R is the test drum radius, in metres

5.1.3. Torque method at drum axis

Calculate: $F_{pl} = T_t/R$

Where:

T_t is the input torque in newton metres, as determined in paragraph 4.6.1,

R is the test drum radius, in metres.

5.1.4. Power method at drum axis

Calculate: $F_{pl} = \frac{3{,}6V \times A}{U_n}$

Where:

V is the electrical potential applied to the machine drive, in volts,

A is the electric current drawn by the machine drive, in amperes,

U_n is the test drum speed, in kilometres per hour.

5.1.5. Deceleration method

Calculate the parasitic losses F_{pl}, in newtons.

$$F_{pl} = \frac{I_D}{R}\left(\frac{\Delta\omega_{D0}}{\Delta t_0}\right) + \frac{I_T}{R_r}\left(\frac{\Delta\omega_{T0}}{\Delta_{\ 0}}\right)$$

Where:

I_D is the test drum inertia in rotation, in kilogram metres squared,

R is the test drum surface radius, in metres,

$\Delta\omega_{D0}$ is the test drum angular speed increment, drum without tyre, in radians per second,

Δt_0 is the time increment chosen for the measurement of the parasitic losses without tyre, in seconds,

I_T is the spindle, tyre and wheel inertia in rotation, in kilogram metres squared,

R_r is the tyre rolling radius, in metres,

$\Delta\omega_{T0}$ is the tyre angular speed increment, unloaded tyre, in radians per second.

or

$$F_{pl} = \frac{I_D}{R} j_{D0} + \frac{I_T}{R_r} j_{T0}$$

Where:

I_D is the test drum inertia in rotation, in kilogram metres squared,

R is the test drum surface radius, in metres,

j_{D0} is the deceleration of the test drum, without tyre, in radians per second squared,

I_T is the spindle, tyre and wheel inertia in rotation, in kilogram metres squared,

R_r is the tyre rolling radius, in metres,

j_{T0} is the deceleration of unloaded tyre, in radians per second squared.

5.2. Rolling resistance calculation

5.2.1. General

The rolling resistance F_r, expressed in newtons, is calculated using the values obtained by testing the tyre to the conditions specified in this Regulation and by subtracting the appropriate parasitic losses F_{pl}, obtained according to paragraph 5.1. above.

5.2.2. Force method at tyre spindle

The rolling resistance Fr, in newtons, is calculated using the equation

$F_r = F_t[1 + (r_L/R)] - F_{pl}$

Where:

F_t is the tyre spindle force in newtons,

F_{pl} represents the parasitic losses as calculated in paragraph 5.1.2. above,

r_L is the distance from the tyre axis to the drum outer surface under steady-state conditions, in metres,

R is the test drum radius, in metres.

5.2.3. Torque method at drum axis

The rolling resistance F_r, in newtons, is calculated with the equation

$$F_r = \frac{T_t}{R} - F_{pl}$$

Where:

T_t is the input torque, in newton metres,

F_{pl} represents the parasitic losses as calculated in paragraph 5.1.3. above,

R is the test drum radius, in metres.

5.2.4. Power method at drum axis

The rolling resistance F_r, in newtons, is calculated with the equation:

$$F_r = \frac{3{,}6V \times A}{U_n} - F_{pl}$$

Where:

V = is the electrical potential applied to the machine drive, in volts,

A = is the electric current drawn by the machine drive, in amperes,

U_n = is the test drum speed, in kilometres per hour,

F_{pl} = represents the parasitic losses as calculated in paragraph 5.1.4. above.

5.2.5. Deceleration method

The rolling resistance Fr, in newtons, is calculated using the equation: $Fr = \frac{I_D}{R}\left(\frac{\Delta\omega_V}{\Delta t_V}\right) + \frac{R \times I_T}{R_r^2}\left(\frac{\Delta\omega_V}{\Delta t_V}\right) - F_{pl}$

Where:

I_D is the test drum inertia in rotation, in kilogram metres squared,

R is the test drum surface radius, in metres,

F_{pl} represents the parasitic losses as calculated in paragraph 5.1.5. above,

Δt_v is the time increment chosen for measurement, in seconds,

$\Delta\omega_v$ is the test drum angular speed increment, without tyre, in radians per second,

I_T is the spindle, tyre and wheel inertia in rotation, in kilogram metres squared,

R_r is the tyre rolling radius, in metres,

F_r is the rolling resistance, in newtons.

or

$$Fr = \frac{I_D}{R} j_V + \frac{R \times I_T}{R_r^2} j_V - F_{pl}$$

Where:

I_D is the test drum inertia in rotation, in kilogram metres squared,

R is the test drum surface radius, in metres,

F_{pl} represents the parasitic losses as calculated in paragraph 5.1.5. above,

j_V is the deceleration of the test drum, in radians per second squared,

I_T is the spindle, tyre and wheel inertia in rotation, in kilogram metres squared,

R_r is the tyre rolling radius, in metres,

F_r is the rolling resistance, in newtons.

6. Data analysis

6.1. Rolling resistance coefficient

The rolling resistance coefficient C_r is calculated by dividing the rolling resistance by the load on the tyre:

$$Cr = \frac{F_r}{L_m}$$

Where:

F_r is the rolling resistance, in newtons,

L_m is the test load, in kN.

6.2. Temperature correction

If measurements at temperatures other than 25 °C are unavoidable (only temperatures not less than 20 °C or more than 30 °C are acceptable), then a correction for temperature shall be made using the following equation, with:

F_{r25} is the rolling resistance at 25 °C, in newtons:

$$F_{r25} = F_r\left[1 + K\left(t_{amb} - 25\right)\right]$$

Where:

F_r is the rolling resistance, in newtons,

t_{amb} is the ambient temperature, in degrees Celsius,

K is equal to:
0.008 for class C1 tyres
0.010 for classes C2 and C3 tyres with a load index equal or lower than 121
0.006 for class C3 tyres with a load index greater than 121

6.3. Drum diameter correction

Test results obtained from different drum diameters shall be compared by using the following theoretical formula:

$F_{r02} \cong KF_{r01}$

With:

$$K = \sqrt{\frac{(R_1/R_2)(R_2 + r_T)}{(R_1 + r_T)}}$$

Where:

R_1 is the radius of drum 1, in metres,

R_2 is the radius of drum 2, in metres,

r_T is one-half of the nominal design tyre diameter, in metres,

F_{r01} is the rolling resistance value measured on drum 1, in newtons,

F_{r02} is the rolling resistance value measured on drum 2, in newtons.

6.4. Measurement result

Where *n* measurements are greater than 1, if required by paragraph 4.6. above, the measurement result shall be the average of the C_r values obtained for the *n* measurements, after the corrections described in paragraphs 6.2. and 6.3. above have been made. Following this method, final C_r results shall be expressed in N/kN and rounded to the first decimal place according to ISO 80000-1:2009, B.3, rule B.

6.5. The laboratory shall ensure that, based on a minimum of three measurements, the machine maintains the following values of σ_m, as measured on a single tyre:

$\sigma_m \leq 0.075$ N/kN for tyres of classes C1 and C2

$\sigma_m \leq 0.06$ N/kN for tyres of class C3

If the above requirement for σ_m is not met, the following formula shall be applied to determine the minimum number of measurements n (rounded to the immediate superior integer value) that are required by the machine to qualify for conformance with this Regulation.

$n = (\sigma_m / x)^2$

Where:

x = 0.075 N/kN for tyres of classes C1 and C2

x = 0.06 N/kN for tyres of class C3

If a tyre needs to be measured several times, the tyre/wheel assembly shall be removed from the machine between the successive measurements.

If the removal/refitting operation duration is less than 10 minutes, the warm-up durations indicated in paragraph 4.3. above may be reduced to:

(a) 10 minutes for tyres of class C1;

(b) 20 minutes for tyres of class C2;

(c) 30 minutes for tyres of class C3.

6.6. Monitoring of the laboratory control tyre shall be carried out at intervals no greater than one month. Monitoring shall include a minimum of 3 separate measurements taken during this one month period. The average of the 3 measurements taken during a given one-month period shall be evaluated for drift from one monthly evaluation to another.

Annex 6 - Appendix 1

Test equipment tolerances

1. Purpose

The limits specified in this appendix are necessary, but may not be sufficient, in order to achieve suitable levels of repeatable test results, which can also be correlated among various test laboratories.

2. Test rims

2.1. Width

For passenger car tyre rims (class C1 tyres), the test rim width shall be the same as the measuring rim determined in ISO 4000-1:2021, clause 6.2.2.

For truck and bus tyres (classes C2 and C3), the rim width shall be the same as the measuring rim determined in ISO 4209-1:2001, clause 5.1.3.

In cases where the width is not defined in the above mentioned ISO Standards, the rim width as defined by one of the standards organizations as specified in Appendix 4 to Annex 6 may be used.

2.2. Run-out

In case vehicle rims are used, the run-out shall meet the following criteria:

(i) for class C1 tyres, class C2 tyres and for class C3 tyres with LI ≤ 121:

(a) Maximum radial run-out: 0.5 mm;

(b) Maximum lateral run-out: 0.5 mm;

(ii) for class C3 tyres with LI ≥ 122:

(a) Maximum radial run-out: 2.0 mm,

(b) Maximum lateral run-out: 2.0 mm.

3. Drum / tyre alignment

General:

Angle deviations are critical to the test results.

3.1. Load application

The direction of tyre loading application shall be kept normal to the test surface and shall pass through the wheel centre within:

(a) 1 mrad for the force method;

(b) 5 mrad for the torque, power and deceleration methods.

3.2. Tyre alignment

3.2.1. Camber angle

The plane of the wheel shall be perpendicular to the test surface within 2 mrad for all methods.

3.2.2. Slip angle

The plane of the tyre shall be parallel to the direction of the test surface motion within 1 mrad for all methods.

4. Control accuracy

Test conditions shall be maintained at their specified values, independent of perturbations induced by the tyre and rim non-uniformity, such that the overall variability of the rolling resistance measurement is minimized. In order to meet this requirement, the average value of measurements taken during the rolling resistance data collection period shall be within the accuracies stated as follows:

(a) Tyre loading:

(i) For class C1 tyres, class C2 tyres and for class C3 tyres with LI ≤ 121: ±20 N or ±0.5 per cent, whichever is greater;

(ii) For class C3 tyres with LI ≥ 122: ±45 N or ±0.5 per cent whichever is greater;

(b) Cold inflation pressure: ±3 kPa;

(c) Surface speed:

(i) ±0.2 km/h for the power, torque and deceleration methods;

(ii) ±0.5 km/h for the force method;

(d) Time:

(i) ±0.02 s for the time increments specified in Annex 6, paragraph 3.5.(b) for the data acquisition in the deceleration method in $\Delta\omega/\Delta t$ form;

(ii) ±0.2 per cent for the time increments specified in Annex 6, paragraph 3.5.(a) for the data acquisition in the deceleration method in $d\omega/dt$ form;

(iii) ±5 per cent for the other time durations specified in Annex 6.

5. Instrumentation accuracy

The instrumentation used for readout and recording of test data shall be accurate within the tolerances stated below:

Parameter	class C1 tyres, class C2 tyres and class C3 tyres with LI ≤ 121	class C3 tyres with LI ≥ 122
Tyre load	±10 N or ±0.5 % ([a])	±30 N or ±0.5 % ([a])
Inflation pressure	±1 kPa	±1.5 kPa
Spindle force	±0.5 N or ±0.5 % ([a])	±1.0 N or ±0.5 % ([a])
Torque input	±0.5 Nm or ±0.5 % ([a])	±1.0 Nm or ±0.5 % ([a])
Distance	±1 mm	±1 mm
Electrical power	±10 W	±20 W
Temperature	±0.2 °C	
Surface speed	±0.1 km/h	
Time	±0.01 s - ±0.1 % - ±10 s ([b])	
Angular velocity	±0.1 %	

([a]) Whichever is greater.
([b]) ±0.01 s for the time increments specified in Annex 6, paragraph 3.5.(b) for the data acquisition in the deceleration method in $\Delta\omega/\Delta t$ form
±0.1 per cent for the time increments specified in Annex 6, paragraph 3.5.(a) for the data acquisition in the deceleration method in $d\omega/dt$ form
± 10 sec for the other time durations specified in Annex 6.

6. Compensation for load/spindle force interaction and load misalignment for the force method only

Compensation of both load/spindle force interaction ("cross talk") and load misalignment may be achieved either by recording the spindle force for both forward and reverse tyre rotation or by dynamic machine calibration. If spindle force is recorded for forward and reverse directions (at each test condition), compensation is achieved by subtracting the "reverse" value from the "forward" value and dividing the result by two. If dynamic machine calibration is intended, the compensation terms may be easily incorporated in the data reduction.

In cases where reverse tyre rotation immediately follows the completion of the forward tyre rotation, a warm-up time for reverse tyre rotation shall be at least 10 minutes for class C1 tyres and 30 minutes for all other tyre types.

7. Test surface roughness

The roughness, measured laterally, of the new smooth steel drum surface shall have a maximum centreline average height value of 6.3 μm. This value should be reconfirmed in case visible damage should occur.

Note: In cases where a textured drum surface is used instead of a smooth steel surface, this fact is noted in the test report. The surface texture shall then be 180 μm deep (80 grit) and the laboratory is responsible for maintaining the surface roughness characteristics. No specific correction factor is recommended for cases where a textured drum surface is used.

Annex 6 - Appendix 2

(omitted)

Annex 6 - Appendix 3

Test report and test data (Rolling resistance)

Part 1: Report

1. Type Approval Authority or Technical Service: .....

2. Name and address of manufacturer: .....

3. Test report No.: .....

4. Brand name and trade description: .....

5. Tyre class (C1, C2 or C3): .....

6. Category of use: .....

6.1. for use in severe snow conditions (Yes/No)[2] .....

7. Rolling resistance coefficient (temperature and drum diameter corrected): .....

8. Comments (if any): .....

9. Date: .....

10. Signature: .....

Part 2: Test data

1. Date of test: .....

2. Test machine identification and drum diameter/surface: .....

3. Test tyre details: .....

3.1. Tyre size designation and service description: .....

3.2. Tyre brand and trade description: .....

3.3. Reference (test) inflation pressure[(1)]: .....kPa

4. Test data: .....

4.1. Measurement method: .....

4.2. Test speed: .....km/h

4.3. Load: .....N

4.4. Test inflation pressure, initial: .....kPa

4.5. Distance from the tyre axis to the drum outer surface under steady state conditions, r_L: ..... m

4.6. Test rim width and material: .....

4.7. Ambient temperature: ..... °C

4.8. Skim test load (except deceleration method): .....N

5. Rolling resistance coefficient: .....

5.1. Initial value (or average in the case of more than 1): .....N/kN

5.2. Temperature corrected: .....N/kN

5.3. Temperature and drum diameter corrected: .....N/kN

(1) for classes C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

(2) strike out what does not apply.

Annex 6 – Appendix 4

Tyre standards organizations

1. The Tire and Rim Association, Inc. (TRA)

2. The European Tyre and Rim Technical Organisation (ETRTO)

3. The Japan Automobile Tyre Manufacturers' Association (JATMA)

4. The Tyre and Rim Association of Australia (TRAA)

5. South Africa Bureau of Standards (SABS)

6. China Association for Standardization (CAS)

7. Indian Tyre Technical Advisory Committee (ITTAC)

8. International Standards Organisation (ISO)

Annex 6 – Appendix 5

Deceleration method: Measurements and data processing for deceleration value obtaining in differential form dω/dt

1. Record dependency "distance-time" of rotating body decelerated from peripheral with a speed range such as 82 to 78 km/h or 62 to 58 km/h dependent on tyre class (Annex 6, paragraph 3.2., Table 1) in a discrete form (Figure 1) for a rotating body:

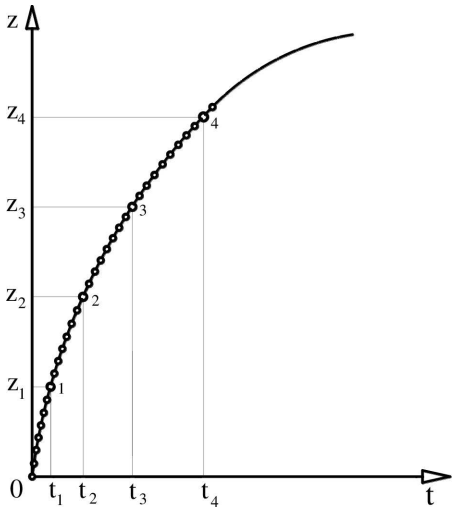
$z = f(t_z)$

Where:

z is a number of body revolutions during deceleration;

t_z is end time of revolution number z in seconds recorded with 6 digits after zero.

Figure 1



Note 1: The lower speed of the recording range may be reduced down to 60 km/h when test speed is 80 km/h and 40 km/h when the test speed is 60 km/h.

2. Approximate recorded dependency by continuous, monotonic, differentiable function:

2.1. Choose the value nearest to the maximum of z dividable by 4 and divide it into 4 equal parts with bounds: 0, $z_1(t_1)$, $z_2(t_2)$, $z_3(t_3)$, $z_4(t_4)$.

2.2. Work out the system for 4 equations each of the form:

$$z_m = Aln\frac{cosB(T_\Sigma - t_m)}{cosBT_\Sigma}$$

Where unknowns:

A is a dimensionless constant,

B is a constant in revolutions per second,

T_Σ is a constant in seconds,

m is the number of bounds shown in figure 1.

Insert in these 4 equations the coordinates of 4-th bound above.

2.3. Take constants A, B and T_Σ as the solution of the equation system of paragraph 2.2. above using iteration process and approximate measured data by formulae:

$$z(t) = Aln\frac{cosB(T_\Sigma - t)}{cosBT_\Sigma}$$

Where:

z(t) is the current continuous angular distance in number of revolutions (not only integer values);

t is time in seconds.

Note 2: Other approximating functions $z = f(t_z)$ may be used if their adequacy is proven.

3. Calculate the deceleration j in revolutions per second squared (s^{-2}) by the formula:

$$j = AB^2 + \frac{\omega^2}{A}$$

Where:

ω is the angular speed in revolutions per second (s^{-1}).

For the case Un = 80 km/h; ω = 22.222/R_r (or R).

For the case Un = 60 km/h; ω = 16.666/R_r (or R).

4. Estimate the quality of approximation of measured data and its accuracy by parameters:

4.1. Standard deviation in percentages:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_1^n \left[1 - \frac{z(t)}{z}\right]^2} \times 100\%$$

4.2. Coefficient of determination

$$R^2 = 1 - \frac{\sum_1^n [z - z(t)]^2}{\sum_1^n [z - \overline{z}]^2}$$

Where:

$$\overline{z} = \frac{1}{n}\sum_{z=1}^n z = \frac{1}{n}(1 + 2 + \ldots + n) = \frac{1+n}{2}$$

Note 3: The above calculations for this variant of the deceleration method for tyre rolling resistance measurement can be executed by the computer program "Deceleration Calculator" downloadable from the WP.29 website ([4]) as well as any software which allows the calculation of nonlinear regression.

([4]) https://unece.org/transport/vehicle-regulations/deceleration-calculator .

ANNEX 7

Procedures for snow performance testing relative to tyres for use in severe snow conditions

1.1. The traction test shall be performed according to ASTM standard:

(a) F1805-06 in case SRTT14 is used as reference tyre or

(b) F1805-20 in case SRTT16 is used as reference tyre.

2. Spin traction method for classes C1 and C2 tyres (traction force test per paragraph 6.5. (b) of this Regulation).

The test procedure of ASTM standard F1805-06 or F1805-20, as applicable according to paragraph 1.3., shall be used to assess snow performance through the traction performance index (TPI) on medium pack snow (The snow compaction index measured with a CTI penetrometer [1] shall be between 70 and 80).

2.1. The test course surface shall be composed of a medium pack snow surface, as characterized in table A2.1 of ASTM standard F1805-06 or ASTM F1805-20, as applicable.

2.2. The tyre load for testing shall be as per option 2 in paragraph 11.9.2. of ASTM standard F1805-06 or ASTM F1805-20, as applicable. When the SRTT16 is used as reference tyre, it shall be tested with a load of 531 kg at an inflation pressure of 240 kPa (cold).

2.3. The snow grip index (SG) of a candidate tyre Tn shall be computed as follows:

$$SG(Tn) = f \bullet \frac{TPI}{100}$$

where

(a) $f = 1.000$ when using SRTT14 as reference tyre per ASTM F1805-06, and

(b) $f = 0.987$ when using SRTT16 as reference tyre per ASTM F1805-20,

and

TPI denotes the traction performance index as defined in ASTM F1805-06 or ASTM F1805-20, as applicable.

3. Braking on snow method for Class C1 and C2 tyres

3.1. General conditions

3.1.1. Test course

The braking tests shall be done on a flat test surface of sufficient length and width, with a maximum 2 per cent gradient, covered with packed snow.

The snow surface shall be composed of a hard packed snow base at least 3 cm thick and a surface layer of medium packed and prepared snow about 2 cm thick.

The air temperature, measured about one metre above the ground, shall be between –15 °C and –2 °C; the snow temperature, measured at a depth of about one centimetre, shall be between –15 °C and –4 °C.

It is recommended to avoid direct sunlight, large variations of sunlight or humidity, as well as wind.

The snow compaction index measured with a CTI penetrometer shall be between 75 and 85.

[1] See appendix of ASTM standard F1805-06 for details.

3.1.2. Vehicle

The test shall be conducted with a standard production vehicle in good running order and equipped with an ABS system.

The vehicle used shall be such that the loads on each wheel are appropriate to the tyres being tested. Several different tyre sizes can be tested on the same vehicle.

3.1.3. Tyres

The tyres should be "broken-in" prior to testing to remove spew, compound nodules or flashes resulting from the moulding process. The tyre surface in contact with snow shall be cleaned before performing a test.

Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests. Tyre pressures shall then be adjusted to the values specified for the test.

In case a vehicle cannot accommodate both the reference and candidate tyres, a third tyre ("control" tyre) may be used as an intermediate. First test control vs. reference on another vehicle, then test candidate vs. control on the vehicle.

3.1.4. Load and pressure

3.1.4.1. For class C1 tyres, the vehicle load shall be such that the resulting loads on the tyres are between 60 per cent and 90 per cent of the load corresponding to the tyre load capacity index.

The cold inflation pressure shall be 240 kPa.

3.1.4.2. For class C2 tyres, the vehicle load shall be such that the resulting loads on the tyres are between 60 per cent and 100 per cent of the load corresponding to the tyre load capacity index.

The static tyre load on the same axle should not differ by more than 10 per cent.

The inflation pressure is calculated to run at constant deflection:

For a vertical load higher or equal to 75 per cent of the load capacity of the tyre, a constant deflection is applied, hence the test inflation pressure P_t shall be calculated as follows:

$$P_t = P_r \bullet \left(\frac{Q_t}{Q_r}\right)^{1.25}$$

Q_r is the maximum load associated to the load capacity index of the tyre written on the sidewall

P_r is the inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

Q_t is the static test load of the tyre

For a vertical load lower than 75 per cent of the load capacity of the tyre, a constant inflation pressure is applied, hence the test inflation pressure P_t shall be calculated as follows:

$$P_t = P_r \times (0.75)^{1.25} = 0.7\ P_r$$

P_r is the inflation pressure corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation.

Check the tyre pressure just prior to testing at ambient temperature.

3.1.5. Instrumentation

The vehicle shall be fitted with calibrated sensors suitable for measurements in winter. There shall be a data acquisition system to store measurements.

The accuracy of measurement sensors and systems shall be such that the relative uncertainty of the measured or computed mean fully developed decelerations is less than 1 per cent.

3.1.6. In order to run this test, the Standard Reference Test Tyres as shown in the following table shall be used :

Class C1 tyres	Class C2 tyres
SRTT14 or SRTT16	SRTT16C

3.2. Testing sequences

3.2.1. For every candidate tyre and the standard reference tyre, ABS-braking test runs shall be repeated a minimum of 6 times.

The zones where ABS-braking is fully applied shall not overlap.

When a new set of tyres is tested, the runs are performed after shifting aside the vehicle trajectory in order not to brake on the tracks of the previous tyre.

When it is no longer possible not to overlap full ABS-braking zones, the test course shall be re-groomed.

Required sequence:

6 repeats SRTT, then shift aside to test next tyre on fresh surface

6 repeats Candidate 1, then shift aside

6 repeats Candidate 2, then shift aside

6 repeats SRTT, then shift aside

3.2.2. Order of testing:

If only one candidate tyre is to be evaluated, the order of testing shall be:

R1 - T - R2

Where:

R1 is the initial test of the SRTT, R2 is the repeat test of the SRTT and T is the test of the candidate tyre to be evaluated.

A maximum of two candidate tyres may be tested before repeating the SRTT test, for example:

R1 - T1 - T2 - R2.

3.2.3. The comparative tests of SRTT and candidate tyres shall be repeated on two different days.

3.3. Test procedure

3.3.1. Drive the vehicle at a speed not lower than 28 km/h.

3.3.2. When the measuring zone has been reached, the vehicle gear is set into neutral, the brake pedal is depressed sharply by a constant force sufficient to cause operation of the ABS on all wheels of the vehicle and to result in stable deceleration of the vehicle and held down until the speed is lower than 8 km/h.

3.3.3. The mean fully developed deceleration between 25 km/h and 10 km/h shall be computed from time, distance, speed, or acceleration measurements.

3.4. Data evaluation and presentation of results

3.4.1. Parameters to be reported

3.4.1.1. For each tyre and each braking test, the arithmetic mean $\overline{a}$ and corrected sample standard deviation σ_a of the mfdd shall be computed and reported.

The coefficient of variation CV_a of a tyre braking test shall be computed as:

$$CV_a = 100\% \bullet \frac{\sigma_a}{\overline{a}}$$

with

$$\sigma_a = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(a_i - \overline{a})^2}$$

3.4.1.2 Weighted averages wa_{SRTT} of two successive tests of the SRTT shall be computed taking into account the number of candidate tyres in between:

In the case of the order of testing R1 – T – R2, the weighted average of the SRTT to be used in the comparison of the performance of the candidate tyre shall be taken to be:

$$wa_{\mathrm{SRTT}} = \frac{1}{2}(\overline{a_{\mathrm{R1}}} + \overline{a_{\mathrm{R2}}})$$

Where:

$\overline{a_{Rn}}$ is the arithmetic mean of the mfdd for the n-th test of the SRTT.

In the case of the order of testing R1 – T1 – T2 – R2, the weighted averages wa_{SRTT} of the SRTT to be used in the comparison of the performance of the candidate tyre shall be taken to be:

$wa_{\mathrm{SRTT}} = \frac{2}{3}\overline{a_{\mathrm{R1}}} + \frac{1}{3}\overline{a_{\mathrm{R2}}}$ for comparison with the candidate tyre T1 and

$wa_{\mathrm{SRTT}} = \frac{1}{3}\overline{a_{\mathrm{R1}}} + \frac{2}{3}\overline{a_{\mathrm{R2}}}$ for comparison with the candidate tyre T2..

3.4.1.3. The snow grip index (SG) of a candidate tyre Tn shall be computed from the arithmetic mean $\overline{a_{\mathrm{Tn}}}$ of the mfdd of the tyre Tn and the applicable weighted average wa_{SRTT} of the SRTT as shown in the table:

$$SG(\mathrm{Tn}) = f \bullet \frac{\overline{a_{\mathrm{Tn}}}}{wa_{\mathrm{SRTT}}}$$

where f is given in the following table

Tyre class	Reference tyre	Factor
C1	SRTT14	$f = 1.000$
	SRTT16	$f = 0.980$
C2	SRTT16C	$f = 1.000$

3.4.2. Statistical validations

The sets of repeats of measured or computed mfdd for each tyre should be examined for normality, drift, eventual outliers.

The consistency of the arithmetic means $\overline{a}$ and corrected sample standard deviations σ_a of successive braking tests of SRTT should be examined.

In addition and in order to take in account possible test evolution, the coefficient of validation $CVal_a$(SRTT) is calculated on the basis of the average values of any two consecutive groups of the minimum 6 runs of the Standard Reference Test Tyre according to

$$CVal_a(\mathrm{SRTT}) = 100\% \times \left| \frac{\overline{a_{R2}} - \overline{a_{R1}}}{\overline{a_{R1}}} \right|$$

The coefficient of validation $CVal_a$(SRTT) shall not exceed 5 per cent.

The coefficient of variation CV_a , as defined in paragraph 3.4.1.1. of this Annex, of any braking test shall be less than 6 per cent.

If those conditions are not met, tests shall be performed again after re-grooming the test course.

3.4.3. In the case where the candidate tyres cannot be fitted to the same vehicle as the SRTT, for example, due to tyre size, inability to achieve required loading and so on, comparison shall be made using intermediate tyres, hereinafter referred to as "control tyres", and two different vehicles. One vehicle shall be capable of being fitted with the SRTT and the control tyre and the other vehicle shall be capable of being fitted with the control tyre and the candidate tyre.

3.4.3.1 The snow grip index of the control tyre C relative to the SRTT (SG1) is given by

$$SG1 = SG(\mathrm{C}) = f \bullet \frac{\overline{a_C}}{wa_{\mathrm{SRTT}}}$$

where f is given in paragraph 3.4.1.3., and snow grip index of the candidate tyre Tn relative to the control tyre (SG2) is given by

$$SG2 = \frac{\overline{a_{Tn}}}{wa_C}$$

where wa_C is the applicable weighted average of the control tyre, shall be established using the procedure in paragraphs 3.1. to 3.4.2. above.

The snow grip index of the candidate tyre relative to the SRTT SG(Tn) shall be the product of the two resulting snow grip indices that is given by

$$SG(Tn) = SG1 \bullet SG2.$$

3.4.3.2. The ambient conditions shall be comparable. All tests shall be completed within the same day.

3.4.3.3. The same set of control tyres shall be used for comparison with the SRTT and with the candidate tyre and shall be fitted in the same wheel positions.

3.4.3.4. Control tyres that have been used for testing shall subsequently be stored under the same conditions as required for the SRTT.

3.4.3.5. The SRTT and control tyres shall be discarded if there is irregular wear or damage or when the performance appears to have been deteriorated.

4. Acceleration method for class C3 tyres

4.1. (omitted)

4.2. Methods for measuring snow grip index

Snow performance is based on a test method by which the average acceleration in an acceleration test, of a candidate tyre is compared to that of a standard reference tyre.

The relative performance shall be indicated by a snow grip index (SG).

When tested in accordance with the acceleration test in paragraph 4.7. below, the average acceleration of a candidate snow tyre shall be at least 1.25 compared to one of the two equivalent Standard Reference Test Tyres SRTT19.5 and SRTT22.5.

4.3. Measuring equipment

4.3.1. A sensor suitable for measuring speed and distance covered on snow/ice surface between two speeds must be used.

To measure vehicle speed, a fifth wheel or non-contact speed-measuring system (including radar, GPS …) shall be used.

4.3.2. The following tolerances shall be respected:

(a) For speed measurements: ±1 per cent or 0.5 km/h whichever is greater.

(b) For distance measurements: $\pm 1 \times 10^{-1}$ m

4.3.3. A display of the measured speed or the difference between the measured speed and the reference speed for the test is recommended inside the vehicle so that the driver can adjust the speed of the vehicle.

4.3.4. For Acceleration test covered in paragraph 4.7. below, a display of the slip ratio of the driven tyres is recommended inside the vehicle and shall be used in the particular case of paragraph 4.7.2.1.1. below.

The slip ratio is calculated by

$$\text{Slip Ratio \%} = \left[\frac{\text{Wheel Speed} - \text{Vehicle Speed}}{\text{Vehicle Speed}} \right] \times 100$$

(a) Vehicle speed is measured as defined in 4.3.1. above (m/s)

(b) Wheel speed is calculated on a tyre of the driven axle by measuring its angular velocity and its loaded diameter

$$\text{Wheel Speed} = \pi \times \text{loaded diameter} \times \text{angular speed}$$

Where, π = 3.1416 (m/360deg), the loaded diameter (m) and the angular speed (revolution per second = 360 deg/sec).

4.3.5. A data acquisition system can be used for storing the measurements.

4.4. General conditions

4.4.1. Test course

The test shall be done on a flat test surface of sufficient length and width, with a maximum 2 per cent gradient, covered with packed snow.

4.4.1.1 The snow surface shall be composed of a hard packed snow base at least 3 cm thick and a surface layer of medium packed and prepared snow about 2 cm thick.

4.4.1.2. The snow compaction index measured with a CTI penetrometer shall be between 80 and 90. Refer to the appendix of ASTM F1805 for additional details on measuring method.

4.4.1.3. The air temperature, measured about one metre above the ground, shall be between –15 °C and –2 °C; the snow temperature, measured at a depth of about one centimetre, shall be between –15 °C and –4 °C.

Air temperature shall not vary more than 10 °C during the test.

4.5. Tyres preparation and break-in

4.5.1. Fit the test tyres on rims as per ISO 4209-1:2001 using conventional mounting methods. Ensure proper bead seating by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

4.5.2. The tyres should be "broken-in" prior to testing to remove spew, compound nodules or flashes resulting from moulding process.

4.5.3. Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests.

They should be placed such that they all have the same ambient temperature prior to testing and be shielded from the sun to avoid excessive heating by solar radiation.

The tyre surface in contact with snow shall be cleaned before performing a test.

Tyre pressures shall then be adjusted to the values specified for the test.

4.6. Testing sequence

If only one candidate tyre is to be evaluated, the order of testing shall be:

R1, T, R2

Where:

R1 is the initial test of the SRTT, R2 is the repeat test of the SRTT and T is the test of the candidate tyre to be evaluated.

A maximum of 3 candidate tyres may be tested before repeating the SRTT test, for example: R1, T1, T2, T3, R2.

Recommendations are that the zones where acceleration is fully applied shall not overlap without reworking.

When a new set of tyres is tested, the runs are performed after shifting the vehicle trajectory in order not to accelerate on the tracks of the previous tyre. When it is no longer possible not to overlap full acceleration zones, the test course should be re-groomed.

4.7. Acceleration on snow test procedure for snow grip index of class C3

4.7.1. Principle

The test method covers a procedure for measuring the snow grip performance of commercial vehicle tyres during acceleration, using a commercial vehicle having a Traction Control System (TCS, ASR, etc.).

Starting with a defined initial speed, the full throttle is applied to activate the traction control system, the average acceleration is calculated between two defined speeds.

4.7.2. Vehicle

4.7.2.1. The test shall be conducted with a standard 2 axle commercial vehicle in good running order with:

(a) Low rear axle weight and an engine powerful enough to maintain the average percentage of slip during the test as required in paragraphs 4.7.5.1. and 4.7.5.2.1. below;

(b) A manual gearbox (automatic gearbox with manual shift allowed) having a gear ratio covering the speed range of at least 19 km/h between 4 km/h and 30 km/h;

(c) Differential lock on driven axle is recommended to improve repeatability;

(d) A standard commercial system controlling/limiting the slip of the driving axle during acceleration (Traction Control, ASR, TCS, etc.).

4.7.2.1.1. In the particular case where a standard commercial vehicle equipped with a traction control system is not available, a vehicle without Traction Control/ASR/TCS is permitted provided the vehicle is fitted with a system to display the percentage slip as stated in paragraph 4.3.4. of this Annex and a mandatory differential lock on the driven axle used in accordance with operating procedure 4.7.5.2.1. below. If a differential lock is available it shall be used; if the differential lock, however, is not available, the average slip ratio should be measured on the left and right driven wheel.

4.7.2.2. The permitted modifications are:

(a) Those allowing to increase the number of tyre sizes capable to be mounted on the vehicle;

(b) Those permitting to install an automatic activation of the acceleration and the measurements.

Any other modification of the acceleration system is prohibited.

4.7.3. Vehicle fitting

The rear driven axle may be indifferently fitted with 2 or 4 test tyres if respecting the loading by tyre.

The front steer non driven axle is equipped with 2 tyres having a size suitable for the axle load. These 2 front tyres could be maintained along the test.

4.7.4. Load and inflation pressure

4.7.4.1. The static load on each rear driven test tyres must be between 20 per cent and 55 per cent of the tested tyre load capacity written on the sidewall.

The vehicle front steer total static axle load should be between 60 per cent and 160 per cent of the driven rear total axle load.

The static tyre load on the same driven axle should not differ by more than 10 per cent.

4.7.4.2. The driven tyres inflation pressure shall be 70 per cent of the one written on the sidewall.

The steer tyres are inflated at nominal sidewall pressure.

If the pressure is not marked on the sidewall, refer to the specified pressure in applicable tyre standards manuals corresponding to maximum load capacity.

4.7.5. Testing runs

4.7.5.1. Mount first the set of reference tyres on the vehicle and when on the testing area.

Drive the vehicle at a constant speed between 4 km/h and 11 km/h and the gear ratio capable of covering the speed range of at least 19 km/h for the complete test programme (e.g. R-T1-T2-T3-R).

The recommended gear selected is 3rd or 4th and shall give a minimum 10 per cent average slip ratio in the measured range of speed.

4.7.5.2. In case of traction control system equipped vehicles (already switched "on" before the run) apply full throttle until the vehicle has reached the final speed.

Final speed = Initial speed + 15 km/h

No rearward restraining force shall be applied to the test vehicle.

4.7.5.2.1. In the particular case of paragraph 4.7.2.1.1. of this Annex where a standard commercial vehicle equipped with a traction control system is not available, the driver shall manually maintain the average slip ratio between 10 and 40 per cent (controlled slip procedure in place of the full slip) within the prescribed range of speeds. If a differential lock is not available, the averaged slip ratio difference between the left and right driven wheel shall not be higher than 8 per cent for each run. All the tyres and runs in the test session are performed with controlled slip procedure.

4.7.5.3. Measure the distance between the initial speed and the final speed.

4.7.5.4. For every candidate tyre and the standard reference tyre, the acceleration test runs shall be repeated a minimum of 6 times and the coefficients of variation CV_{AA} shall be lower than or equal to 6 per cent. CV_{AA} shall be calculated for minimum 6 valid runs according to

$$CV_{AA} = 100\% \bullet \frac{\sigma_{AA}}{\overline{AA}}$$

where

$\sigma_{AA} = \sqrt{\frac{1}{N-1}\Sigma_{i=1}^{N}(AA_i - \overline{AA})^2}$ denotes the corrected sample standard deviation and

$\overline{AA}$ the arithmetic mean of the Average Accelerations (AA_i) of N test runs.

4.7.5.5. In case of traction control system equipped vehicle, the average slip ratio shall be in the range from 10 per cent to 40 per cent (calculated as per paragraph 4.3.4. of this Annex).

4.7.5.6. Apply testing sequence as defined in paragraph 4.6. above.

4.8. Processing of measurement results

4.8.1. Calculation of the average acceleration AA

Each time the measurement is repeated, the average acceleration AA (m • s-²) is calculated by

$$AA = \frac{S_f^2 - S_i^2}{2D}$$

Where D (m) is the distance covered between the initial speed S_i (m • s-¹) and the final speed S_f (m • s-¹).

4.8.2. Validation of results

For the candidate tyres:

The coefficient of variation CV_{AA} of the average acceleration is calculated according to the formula in 4.7.5.4. of this Annex for all the candidate tyres. If one coefficient of variation is greater than 6 per cent, discard the data for this candidate tyre and repeat the test.

For the reference tyre:

If the coefficient of variation CV_{AA} of the average acceleration calculated according to the formula in 4.7.5.4. of this Annex for each group of min 6 runs of the reference tyre is higher than 6 per cent, discard all data and repeat the test for all tyres (the candidate tyres and the reference tyre).

In addition and in order to take in account possible test evolution, the coefficient of validation $CVal_{AA}$(SRTT) is calculated on the basis of the average values of any two consecutive groups of minimum 6 runs of the reference tyre according to

$$CVal_{AA}(\mathrm{SRTT}) = 100\% \times \left| \frac{\overline{AA_2} - \overline{AA_1}}{\overline{AA_1}} \right|$$

If the coefficient of validation is greater than 6 per cent, discard the data for all the candidate tyres and repeat the test.

4.8.3. Calculation of the weighted averages

Weighted averages wa_{SRTT} of the average accelerations of two successive tests of the SRTT are calculated according to Table 1:

Table 1

If the number of sets of candidate tyres between two successive runs of the reference tyre is:		and the set of candidate tyres to be qualified is:	then wa_{SRTT} is calculated by applying the following:
1	R – T1 – R	T1	$wa_{\mathrm{SRTT}} = \frac{1}{2}(\overline{AA_{R1}} + \overline{AA_{R2}})$
2	R – T1 – T2 – R	T1	$wa_{\mathrm{SRTT}} = \frac{2}{3}\overline{AA_{R1}} + \frac{1}{3}\overline{AA_{R2}}$
		T2	$wa_{\mathrm{SRTT}} = \frac{1}{3}\overline{AA_{R1}} + \frac{2}{3}\overline{AA_{R2}}$
3	R – T1 – T2 – T3 – R	T1	$wa_{\mathrm{SRTT}} = \frac{3}{4}\overline{AA_{R1}} + \frac{1}{4}\overline{AA_{R2}}$
		T2	$wa_{\mathrm{SRTT}} = \frac{1}{2}(\overline{AA_{R1}} + \overline{AA_{R2}})$
		T3	$wa_{\mathrm{SRTT}} = \frac{1}{4}\overline{AA_{R1}} + \frac{3}{4}\overline{AA_{R2}}$

where $\overline{AA_{Rn}}$ is the arithmetic mean of the average accelerations in the n-th test of the Standard Reference Test Tyre.

4.8.4. Calculation of the relative snow grip index of the tyre

The snow grip index represents the relative performance of the candidate tyre compared to the reference tyre.

$$SG(\mathrm{Tn}) = f \bullet \frac{\overline{AA_{\mathrm{Tn}}}}{wa_{\mathrm{SRTT}}}$$

where $\overline{AA_{Tn}}$ is the arithmetic mean of the average accelerations of the n-th candidate tyre

and f is given in the following table

Reference tyre	Factor
SRTT19.5, SRTT22.5	$f = 1.000$
SRTT19.5 siped	$f = 1.570$
SRTT22.5 siped	$f = 1.680$

4.8.5. Calculation of the slip ratio

The slip ratio can be calculated as the average of slip ratio as mentioned in paragraph 4.3.4. of this Annex or by comparing the average distance referred to in paragraph 4.7.5.3. of this Annex of the minimum 6 runs to the distance of a run done without slip (very low acceleration)

$$\text{Slip Ratio \%} = \left[\frac{\text{Average distance} - \text{No slip distance}}{\text{No slip distance}} \right] \times 100$$

No slip distance means the wheel distance calculated on a run done with a constant speed or a continuous low acceleration.

4.9. Snow grip performance comparison between a candidate tyre and a reference tyre using a control tyre

4.9.1. Scope

When the candidate tyre size is significantly different from the reference tyre a direct comparison on the same vehicle may be not possible. This is an approach using an intermediate tyre, hereinafter called the control tyre.

4.9.2. Principle of the approach

The principle lies upon the use of a control tyre and 2 different vehicles for the assessment of a candidate tyre in comparison with a reference tyre.

One vehicle can fit the reference tyre and the control tyre, the other the control tyre and the candidate tyre. All conditions are in conformity with paragraph 4.7. above.

The first assessment is a comparison between the control tyre C and the reference tyre. The result (snow grip index SG1) is the relative efficiency of the control tyre compared to the reference tyre.

$$SG1 = f \bullet \frac{\overline{AA_C}}{wa_{SRTT}}$$

The second assessment is a comparison between the candidate tyre Tn and the control tyre C. The result (snow grip index SG2) is the relative efficiency of the candidate tyre compared to the control tyre.

$$SG2 = \frac{\overline{AA_{Tn}}}{\overline{AA_C}}$$

The second assessment is done on the same track as the first one. The air temperature must be in the range of ±5 °C of the temperature of the first assessment. The control tyre set is the same set as the set used for the first assessment.

The snow grip index SG of the candidate tyre compared to the reference tyre is deduced by multiplying the relative efficiencies calculated above:

$$SG = SG1 \bullet SG2$$

4.9.3. Selection of a set of tyres as a control tyre set

A control tyre set is a group of identical tyres made in the same factory during one week period.

4.10. Storage and preservation

Before the first assessment (control tyre / reference tyre), normal storage conditions can be used. It is necessary that all the tyres of a control tyre set have been stored in the same conditions.

As soon as the control tyre set has been assessed in comparison with the reference tyre, specific storage conditions shall be applied for control tyres replacement.

When irregular wear or damage results from tests, or when wear influences the test results, the use of the tyre shall be discontinued.

Annex 7 - Appendix 1

Pictogram definition of "Alpine Symbol"



Minimum 15 mm base and 15 mm height.

Above drawing not to scale.

Annex 7 - Appendix 2

Test reports and test data for classes C1 and C2 tyres

Part 1 - Report

1. Type Approval Authority or Technical Service: .....

2. Name and address of manufacturer: .....

3. Test report No.: .....

4. Brand name and trade description: .....

5. Tyre class: .....

6. Category of use: .....

7. Snow grip index SG

7.1. Test procedure and SRTT used .....

8. Comments (if any): .....

9. Date: .....

10. Signature: .....

Part 2 - Test data

1. Date of test: .....

2. Location of test track: .....

2.1. Test track characteristics:

	At start of tests	At end of tests	Specification
Weather			
Ambient temperature			–15 °C to –2 °C
Snow temperature			–15 °C to –4 °C
CTI index			75 to 85
Other			

3. Test vehicle (make, model and type, year): .....

4. Test tyre details and data .....

	SRTT (1st test)	Candidate 1	Candidate 2	SRTT (2nd test)
Brand name				
Trade description/ commercial name				
Tyre size designation				
Service description				
Test rim width code				
Reference (test) inflation pressure[1] (kPa)				
Tyre loads F/R (kg)				
Tyre loads F/R (% of load associated to LI[2])				
Tyre pressure F/R (kPa)				

5. Test results: mean fully developed decelerations ($m \cdot s^{-2}$) / traction coefficient [3]

Run number	Specification	SRTT (1st test)	Candidate 1	Candidate 2	SRTT (2nd test)
1					
2					
3					
4					
5					
6					
Mean					

Run number	Specification	SRTT (1st test)	Candidate 1	Candidate 2	SRTT (2nd test)
Standard deviation					
Coefficient of variation	$CV_a \leq 6$ %				
Coefficient of Validation	$CVal_a$(SRTT) ≤ 5 %				
SRTT weighted average					
Factor *f*					
Snow grip index		1.00			

(1) for class C2 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation
(2) for class C2 tyres, refer to single load
(3) Strike out what does not apply.

Annex 7 - Appendix 3

Test reports and test data for class C3 tyres

Part 1 - Report

1. Type Approval Authority or Technical Service: .....

2. Name and address of manufacturer: .....

3. Test report No.: .....

4. Brand name and trade description: .....

5. Tyre class: .....

6. Category of use: .....

7. Snow grip index relative to SRTT according to paragraph 6.5.1.

7.1. Test procedure and SRTT used .....

8. Comments (if any): .....

9. Date: .....

10. Signature: .....

Part 2 - Test data

1. Date of test: .....

2. Location of test track: .....

2.1. Test track characteristics:

	At start of tests	At end of tests	Specification
Weather			
Ambient temperature			−15 °C to −2 °C
Snow temperature			−15 °C to −4 °C
CTI index			80 to 90
Other			

3. Test vehicle (make, model and type, year): .....

4. Test tyre details and data:

	SRTT (1st test)	Candidate 1	Candidate 2	Candidate 3	SRTT (2nd test)
Brand name					
Trade description/ commercial name					
Tyre size designation					
Service description					
Test rim width code					
Reference (test) inflation pressure[1] (kPa)					
Tyre loads F/R (kg)					
Tyre loads F/R (% of load associated to LI[2])					
Tyre pressure F/R (kPa)					

5. Test results: average accelerations ($m \cdot s^{-2}$)

Run number	Specification	SRTT (1st test)	Candidate 1	Candidate 2	Candidate 3	SRTT (2nd test)
1						
2						
3						
4						
5						
6						

Run number	Specification	SRTT (1st test)	Candidate 1	Candidate 2	Candidate 3	SRTT (2nd test)
Mean						
Standard deviation						
Slip ratio (per cent)						
Coefficient of variation	$CV_a \leq 6$ %					
Coefficient of Validation	$CVal_a$(SRTT) ≤ 6 %					
SRTT weighted average						
f						
Snow grip index		1.00				

(1) corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation

(2) refer to single load

ANNEX 8

Procedures for ice performance testing relative to ice grip tyres of class C1

1. Specific definitions for ice performance test when different from existing ones

1.1. "*Non-consecutive braking test cycles*" means test cycles of braking tests performed at least after minimum refreshing (or new preparation) of the ice surface, or on a different test lane, or in a different day.

1.2. "*Reference load*" (Q_{ref}) means the theoretical load capacity of a tyre at the test inflation pressure. It is expressed in kilograms. It may exceed the maximum load-carrying capacity of the test tyre as indicated by its load index.

1.3. "*Load-on-tyre rate*" (R_{LoT}) means the actual static tyre load on the test vehicle divided by the reference load.

1.4. "*Set of tyres*" means a set of four tyres.

2. Braking on ice method for class C1 tyres

The ice performance is determined by a testing method in which the mean fully developed deceleration of a candidate tyre in an ABS braking test on a flat surface made of ice is compared with that of a reference tyre.

For determination of the ice performance, braking tests of a candidate tyre shall be performed in three (3) non-consecutive braking test cycles.

The relative performance shall be indicated by an ice grip index (G_I).

2.1. General conditions

2.1.1. Test course

2.1.1.1. The braking tests shall be done on a flat test surface of sufficient length and width covered with smooth ice with a maximum of 2 per cent gradient.

2.1.1.2. The test course surface shall be flat, smooth, polished ice and watered around at least one hour before testing. The water used to make the ice shall be clean and free of any solid inclusions. Before starting the test, the braking line should be conditioned by conducting braking runs with a set of tyres not involved in the test program until the friction level stabilizes. The exact same test line shall be used for all braking test repetitions.

2.1.1.3. The surface grip level shall be controlled by measurements with the reference tyre. The mean fully developed deceleration of the reference tyre shall be not less than 0.9 m/s^2 and not greater than 1.6 m/s^2 in each braking test.

2.1.1.4. The air temperature, measured about one meter above the ground, shall be between −15 °C and +4 °C; the ice temperature, measured on the surface of the conditioned line, shall be between −15 °C and −5 °C. Both air and ice temperatures shall be reported for each tested tyre.

2.1.1.5. Test cannot be conducted during snow fall or rain fall or any atmospheric precipitation. It is recommended to avoid direct sunlight, large variations of sunlight or humidity, as well as wind.

2.1.1.6. Indoor as well as outdoor facilities for ice tracks are accepted as far as the above requirements are met.

2.1.2. Vehicle

2.1.2.1. The test shall be conducted with a commercialized-model passenger car equipped with an ABS system in mechanical condition according to car manufacturer recommendations. Permitted modifications are as follows: those allowing the number of tyres sizes that can be mounted on the vehicle to be increased, those permitting automatic activation of the braking device to be installed. Any other modification of the braking system is prohibited. Increasing load on tyre by adding weight into the vehicle is permitted. Rim adapters or "spacers" for mounting wheels on the vehicle shall not exceed 60 mm.

2.1.3. Tyres

2.1.3.1. Standard Reference Test Tyre

For the evaluation of the ice performance of class C1 tyres, the Standard Reference Test Tyre SRTT16 shall be used. The reference tyre shall not be older than 30 months starting from the production week and shall be stored in accordance with ASTM F2493 – 23.

2.1.3.2. Tyres preparation

2.1.3.2.1. Fit each test tyres on an approved rim pursuant to ISO 4000-1:2021 using conventional mounting methods. Subject to the foregoing, the rim width code shall not differ more than 0.5 from the measuring rim. If a commercialized rim is not available for the test vehicle, it will be acceptable to use a rim whose rim width code differs by 1.0 from the measuring rim width code. Ensure proper bead seating by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

2.1.3.2.2. The tyres should be "broken-in" prior to testing (at least 100 km on dry roads or with an equivalent method) to ensure stable performance and to remove spew, compound nodules or flash resulting from the moulding process. The tyre designed tread depth and designed tread block or rib integrity shall not change significantly with break-in, which means the pace and "severity" of the break-in run needs to be carefully controlled to avoid such changes.

2.1.3.2.3. It is acceptable to recondition a test tyre before the braking test to reach a stabilized performance level ([1]).

2.1.3.2.4. The tyre surface in contact with ice shall be cleaned before performing the test, removing snow and dirt.

2.1.3.2.5. Tyre and wheel assemblies shall be conditioned at the ambient temperature (outdoor or indoor depending on the test facility) at least two hours before they are fitted on the vehicle for tests. Tyre pressures shall then be adjusted to the values specified for the test.

2.1.3.2.6. In case a vehicle cannot accommodate both the reference and candidate tyres, a third tyre ("control" tyre) may be used as an intermediate. First, test the control tyre versus the reference on a suitable vehicle, then test the candidate tyre versus the control tyre on the selected vehicle.

2.1.4. Tyre load and inflation pressure

2.1.4.1. Tyre load and inflation pressure shall be adjusted according to Table 1 (depending on a direct comparison of candidate and reference tyre on the same vehicle, or an indirect comparison by using a control tyre and another vehicle).

([1]) It can be done, for example, by driving 5 km to 10 km on rough road surfaces or equivalent.

Table 1

Tyre load and inflation pressure

	Reference tyre	Control tyre	Candidate tyre
Direct comparison	Inflation pressure: 230 kPa ≤ p_{test} ≤ 260 kPa Load-on-tyre rate: 65 % ≤ R_{LoT} (R) ≤ 75 %		Inflation pressure: 190 kPa ≤ p_{test} ≤ 270 kPa Load-on-tyre rate: R_{LoT}(R) − 15% ≤ R_{LoT}(T) ≤ R_{LoT}(R) + 15%
Indirect comparison	Vehicle 1: Inflation pressure: 230 kPa ≤ p_{test} ≤ 260 kPa Load-on-tyre rate: 65 % ≤ $R_{LoT,1}$(R) ≤ 75 %	Vehicle 1: Inflation pressure: 190 kPa ≤ p_{test} ≤ 270 kPa Load-on-tyre rate: $R_{LoT,1}$(R) − 15% ≤ $R_{LoT,1}$(C) ≤ $R_{LoT,1}$(R) + 15%	
		Vehicle 2: Inflation pressure: 190 kPa ≤ p_{test} ≤ 270 kPa Load-on-tyre rate: $R_{LoT,1}$(C) − 15% ≤ $R_{LoT,2}$(C) ≤ $R_{LoT,1}$(C) + 15%	Vehicle 2: Inflation pressure: 190 kPa ≤ p_{test} ≤ 270 kPa Load-on-tyre rate: 60 % ≤ $R_{LoT,2}$(T) ≤ 90 %

Load-on-tyre rate R_{LoT} is given by

$$R_{LoT} = 100\% \bullet \frac{Q_{tyre}}{Q_{ref}}$$

where

Q_{tyre} is the actual static tyre load on the test vehicle, and

Q_{ref} is the reference load at the test inflation pressure as determined below.

2.1.4.2. The reference load Q_{ref} at the test inflation pressure p_{test} is determined according to

$$Q_{ref} = Q_{LI} \bullet \left(\frac{p_{test}}{p_{ref}}\right)^{0.8}$$

where

Q_{LI} is the maximum tyre load-carrying capacity according to its load index, and

p_{ref} is the reference inflation pressure as defined in Table 2.

Table 2

Reference inflation pressures

Tyre	p_{ref} (kPa)
Reference tyre	250
Standard tyre	250
Reinforced tyre (or "extra load" tyre)	290

2.1.5. Instrumentation

2.1.5.1. The vehicle shall be fitted with calibrated sensors suitable for measurements in cold and icy conditions. There shall be a data acquisition system to store measurements.

2.1.5.2. The accuracy of measurement sensors and systems shall be such that would allow a relative uncertainty ([2]) of less than or equal to 1 per cent on the measured or computed mean fully developed deceleration ([3]).

2.2. Testing order and braking test cycles

2.2.1. For each braking test of a test tyre, at least nine (9) valid test runs shall be performed.

2.2.2. Within one braking test cycle, up to two (2) candidate tyres may be tested. Several braking test cycles may be combined and the final braking test of the reference tyre of one braking test cycle may serve as the initial braking test of the subsequent braking test cycle.

EXAMPLE 1

For a braking test cycle with two candidate tyres, the order of testing is

$R_i - T_1 - T_2 - R_f$

where

R_i/R_f is the initial/final braking test of the reference tyre and

T_1, T_2 are the braking tests of the two candidate tyres to be evaluated.

EXAMPLE 2

The run order for a series of braking test cycles with a total of four (4) candidate tyre sets (T_1 to T_4) would be the following:

$R_i - T_1 - T_2 - R_f/R_i - T_3 - T_4 - R_f$,

where the final braking test of the reference tyre set (R_f) of the first braking test cycle serves as initial braking test (R_i) of the second braking test cycle.

For any candidate tyre at least three (3) non-consecutive braking test cycles shall be performed.

2.3. Test procedure

2.3.1. The vehicle shall be fitted on all four positions with the same tyres.

2.3.2. Drive the vehicle in a straight line at a speed about 5 km/h higher than the upper speed of the evaluation interval.

([2]) Suitable methods for determining the relative measurement uncertainty can be found, for example, in ISO/IEC Guide 98-3, Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995).

([3]) For example, in case the mean fully developed deceleration is computed according to paragraph 2.4.1.1. of this Annex, the accuracy of the measurements sensors or systems for the measurements of the distance (s) and of the speeds (v_i and v_j) should be such that the composition of their relative uncertainties, based on 2.4.1.1. of this Annex would allow to determine the mean fully developed deceleration with a relative uncertainty of less than or equal to 1 per cent.

2.3.3. When the measuring zone has been reached, set the vehicle gear into neutral, press the brake pedal sharply down with a force sufficient to cause operation of the ABS on all wheels of the vehicle and to result in a stable deceleration of the vehicle and hold it down until the speed is 0 km/h.

2.3.4. The mean fully developed deceleration dm shall be determined either between 15 km/h and 5 km/h or between 20 km/h and 5 km/h. It shall be computed from measurements of either time (expressed in s), distance (expressed in m), or deceleration (expressed in m • s^{-2}). For each test run in the braking tests (3 or 4) of a braking test cycle and for all test tyres, the same evaluation speed interval shall be used.

2.4. Data evaluation and presentation of results

2.4.1. Data evaluation

2.4.1.1. For a distance measurement, the mean fully developed deceleration d_m in a test run is computed as:

$$d_m = \frac{v_i^2 - v_f^2}{2s}$$

where

v_i is the initial speed expressed in m • s^{-1}

v_f is the final speed expressed in m • s^{-1}, and

s is the distance, expressed in metres, covered between the initial speed and the final speed.

2.4.1.2. The highest and the lowest values (in total two (2) runs) of the at least nine valid test runs shall be disregarded in the evaluation of each braking test.

2.4.1.3. For each braking test in a braking test cycle, the arithmetic mean $d_{m,ave}$ and the standard deviation σ_d of the mean fully developed deceleration and the coefficient of variation CV_d shall be computed and reported:

$$\sigma_d = \sqrt{\frac{1}{N-1} \bullet \Sigma_{j=1}^{N} (d_{m,j} - d_{m,ave})^2}$$

and

$$CV_d = 100\% \bullet \frac{\sigma_d}{d_{m,ave}}$$

2.4.2. Calculation of the braking test ice grip index

2.4.2.1. For the calculation of the ice grip index $G_{I,k}(T_n)$ for an individual braking test, the mean fully developed deceleration of the reference tyre is adjusted according to the positioning of each candidate tyre (T_n) within a braking test cycle.

2.4.2.2. This adjusted mean fully developed deceleration $d_{m,adj}(R)$ of the reference tyre is calculated in accordance with Table 3, where $d_{m,ave}(R_i)$ and $d_{m,ave}(R_f)$ are the arithmetic means of the mean fully developed decelerations in the initial and in the final braking test of the reference tyre within a braking test cycle.

Table 3

Calculation of the adjusted mean fully developed deceleration $d_{m,adj}(R)$ of the reference tyre

If the number and the sequence of candidate tyres within one braking test cycle is		and the candidate tyre to be qualified is	the corresponding adjusted mean fully developed deceleration $d_{m,adj}(R)$ of the reference tyre is calculated as follows
1	$R_i - T_1 - R_f$	T_1	$d_{m,adj}(R) = 1/2 \bullet [d_{m,ave}(R_i) + d_{m,ave}(R_f)]$
2	$R_i - T_1 - T_2 - R_f$	T_1	$d_{m,adj}(R) = 2/3 \bullet d_{m,ave}(R_i) + 1/3 \bullet d_{m,ave}(R_f)$
		T_2	$d_{m,adj}(R) = 1/3 \bullet d_{m,ave}(R_i) + 2/3 \bullet d_{m,ave}(R_f)$

2.4.2.3. For an individual braking test, the ice grip index $G_{I,k}(T_n)$ of the candidate tyre T_n *(n = 1, 2)* relative to the reference tyre is calculated as:

$$G_{I,k}(Tn) = \frac{d_{m,ave}(T_n)}{d_{m,adj}(R)}$$

2.4.3. Ice grip index

The ice grip index $G_I(T_n)$ of a candidate tyre shall be computed as the arithmetic mean of the ice grip indices $G_{I,k}(T_n)$ for the individual braking tests in the three non-consecutive braking test cycles as :

$$G_I(Tn) = \frac{1}{3} \bullet [G_{I,1}(Tn) + G_{I,2}(Tn) + G_{I,3}(Tn)]$$

An example of a full test report is given in appendix 2.

2.4.4. Statistical validation

2.4.4.1. The sets of mean fully developed decelerations d_m within each braking test shall be examined for normality, drift, eventual outliers.

2.4.4.2. If the coefficient of variation CV_d of a braking test of a candidate tyre exceeds 6 per cent, this braking test shall be discarded.

2.4.4.3. In the case that

a) the coefficient of variation CV_d of the initial or the final braking test of a reference tyre within a braking test cycle exceeds 6 per cent, or

b) the arithmetic means of the mean fully developed decelerations of the initial and the final braking test of the reference tyre within a braking test cycle exceeds 5 per cent of the average of the two values:

$$CVal(d_m) = 2 \cdot \left| \frac{d_{m,ave}(R_i) - d_{m,ave}(R_f)}{d_{m,ave}(R_i) + d_{m,ave}(R_f)} \right| \cdot 100\% \leq 5\ \%, \text{ or}$$

c) the mean fully developed deceleration of the reference tyre is less than 0.9 m • s^{-2} or greater than 1.6 m • s^{-2} in the initial or the final braking test within a braking test cycle

the complete braking test cycle shall be discarded.

2.4.4.4. For each candidate tyre T_n, the coefficient of variation CV_G of the ice grip indices $G_{I,k}(T_n)$ for the individual braking tests in the three (3) non-consecutive braking test cycles shall be calculated as:

$$CV_G = 100\% \cdot \frac{\sigma_G}{G_I(T_n)}$$

where

$$\sigma_G = \sqrt{\frac{1}{2} \cdot \sum_{k=1}^{3} [G_{I,k}(Tn) - G_I(Tn)]^2}$$

and

$G_I(T_n)$ is the ice grip index of candidate tyre T_n.

2.4.4.5. If the coefficient of variation CV_G exceeds 6%, for this candidate tyre T_n additional braking tests shall be performed in non-consecutive braking cycles, until the coefficient of variation CV_G calculated from any three braking tests of this candidate tyre meets the requirement.

2.4.4.6. The SRTT shall be discarded if it exhibits irregular wear or damage or when the performance appears to have been deteriorated.

2.4.5. Ice performance comparison between a candidate tyre and a reference tyre using a control tyre

2.4.5.1. General

2.4.5.1.1. In case the candidate tyre cannot be fitted on the same vehicle as the reference tyre, for example, due to tyre size, inability to achieve required load-on-tyre rate and required test inflation pressure, comparison shall be made using intermediate tyres, herein referred to as "control tyres", and two different vehicles.

2.4.5.1.2. The control tyre shall pass the ice grip index threshold defined in paragraph 6.5.2. of this Regulation.

2.4.5.1.3. One vehicle shall be capable of being fitted with the reference tyre and the control tyre, and the other vehicle shall be capable of being fitted with the control tyre and the candidate tyre.

2.4.5.2. Ice grip index calculation in case of a control tyre

2.4.5.2.1. In a first series of three non-consecutive braking test cycles, using the procedure described in paragraph 2.1.3.2. to 2.4.4.6. of this Annex in which the control tyre shall be treated as a candidate tyre, the ice grip index $G_{I,1}(C)$ of the control tyre relative to the reference tyre shall be established. In a second series of three non-consecutive braking test cycles, in which the control tyre serves as reference tyre, the ice grip index $G_{I,2}(T)$ of the candidate tyre relative to the control tyre shall be established.

2.4.5.2.2. The ice grip index $G_I(T)$ of the candidate tyre relative to the reference tyre shall be calculated as the product of the two ice grip indices:

$$G_I(T) = G_{I,1}(C) \bullet G_{I,2}(T)$$

2.4.5.3. Boundary conditions

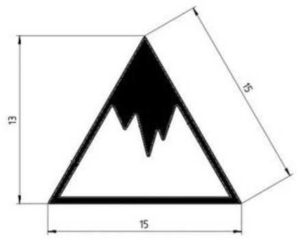
2.4.5.3.1. The same set of control tyres shall be used for comparison with the SRTT and with the candidate tyre and shall be fitted in the same wheel positions.

2.4.5.3.2. Control tyres that have been used for testing shall subsequently be stored under the same conditions as required for the SRTT.

2.4.5.3.3. The SRTT and control tyres shall be discarded if there is irregular wear or damage or when the performance appears to have been deteriorated.

Annex 8 - Appendix 1

Pictogram definition of "Ice Grip Symbol"



Minimum 15 mm base and 13 mm height.

Above drawing not to scale.

Annex 8 - Appendix 2

Test reports and test data for C1 tyres

Part 1 - Report

1. Type Approval Authority or Technical Service: .....

2. Name and address of manufacturer: .....

3. Test report No.: .....

4. Brand name and trade description: .....

5. Tyre class: .....

6. Category of use: .....

7. Ice grip index relative to SRTT

7.1. Test procedure and SRTT used .....

8. Comments (if any): .....

9. Date: .....

10. Signature: .....

Part 2 - Test data: 1st braking test cycle

1. Date of test: .....

2. Location of test track: .....

2.1. Test track characteristics:

	At start of test	At end of test	Specification
Weather			
Ambient temperature			–15 °C to +4 °C
Ice temperature			–15 °C to –5 °C
Other			

3. Test vehicle (make, model and type, year): .....

4. Test tyre details and data .....

	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
Brand name				
Trade description/ commercial name				
Tyre size designation				
Service description				
Test rim width code				
Tyre load FL/FR/RL/RR (kg)				
Load-on-tyre rate (FL/FR/RL/RR) (%)				
Tyre pressure (kPa)				

5. Test results: mean fully developed decelerations ($m \cdot s^{-2}$)

Run number	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
1				
2				
3				
4				
5				
6				
7				
8				
9				
$d_{m,ave}$				
σ_d				
CV_d (≤ 6 %)				

Run number	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
$CVal(d_m)$ (≤ 5%)				
$d_{m,adj}$(R)				
Ice grip index	1.00			

Part 2 - Test data: 2nd braking test cycle

1. Date of test: .....

2. Location of test track: .....

2.1. Test track characteristics:

	At start of test	At end of test	Specification
Weather			
Ambient temperature			–15 °C to +4 °C
Ice temperature			–15 °C to –5 °C
Other			

3. Test vehicle (make, model and type, year): .....

4. Test tyre details and data .....

	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
Brand name				
Trade description/ commercial name				
Tyre size designation				
Service description				
Test rim width code				
Tyre load FL/FR/RL/RR (kg)				
Load-on-tyre rate (FL/FR/RL/RR) (%)				
Tyre pressure (kPa)				

5. Test results: mean fully developed decelerations (m • s^{-2})

Run number	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
1				
2				
3				
4				
5				
6				
7				
8				
9				
$d_{m,ave}$				
σ_d				
CV_d (≤ 6 %)				
$CVal(d_m)$ (≤ 5 %)				
$d_{m,adj}$(R)				
Ice grip index	1.00			

Part 2 - Test data: 3rd braking test cycle

1. Date of test: .....

2. Location of test track: .....

2.1. Test track characteristics:

	At start of test	At end of test	Specification
Weather			
Ambient temperature			–15 °C to +4 °C
Ice temperature			–15 °C to –5 °C
Other			

3. Test vehicle (make, model and type, year): .....

4. Test tyre details and data .....

	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
Brand name				
Trade description/ commercial name				
Tyre size designation				
Service description				
Test rim width code				
Tyre load FL/FR/RL/RR (kg)				
Load-on-tyre rate (FL/FR/RL/RR) (%)				
Tyre pressure (kPa)				

5. Test results: mean fully developed decelerations ($m \cdot s^{-2}$)

Run number	SRTT (Initial braking test)	Candidate 1	Candidate 2	SRTT (final braking test)
1				
2				
3				
4				
5				
6				
7				
8				
9				
$d_{m,ave}$				
σ_d				
CV_d (≤ 6 %)				
$CVal(d_m)$ (≤ 5%)				
$d_{m,adj}(R)$				
Ice grip index	1.00			

ANNEX 9

Procedure for determining the adhesion on wet surfaces of tyres in worn state

1. General part (reserved)

2. Test procedure for tyres of class C1

Principle

Two steps:

1) Preparation of the tyre in worn state

2) Wet grip index evaluation of the tyre in worn state

2.1. Definitions

For the purpose of this Annex, the "*Candidate tyre*" or "*Candidate tyre set*" and the "*Reference tyre*" or "*Reference tyre set*" mentioned in paragraphs 2.19.2. and 2.19.3. shall be read respectively as "*Candidate tyre in worn state*" or "*Candidate tyre set in worn state*" and the "*Reference tyre in worn state*" or "*Reference tyre set in worn state*".

2.1.1. "*Tyre in worn state*" or "*worn tyre*" means, for the purpose of this Regulation, a new tyre artificially worn by reducing the tread depth or, with respect to the reference tyre in worn state, moulded with a tread depth defined in paragraph 2.2.1.2.4.1. of this Annex.

2.1.2. "*Tyre in new state*" means a new tyre before starting to be artificially worn.

2.1.3. "*Groove*" means the space between two adjacent ribs or blocks in the tread pattern.

2.1.4. "*Groove depth*" means the perpendicular distance from a real or calculated reference plane defined by edges of two adjacent ribs to the lowest point in the groove.

2.1.5. "*Reference tread width*" (*C*) is calculated as follows:

$$C = (1.075 - 0.005 \bullet Ra) \bullet S_1^{1.001}$$

Where:

Ra is the nominal aspect ratio as defined as part of tyre size designation in UN Regulation No. 30 except for the sizes listed in Annex V of UN Regulation No. 30 where it is taken as 90 and

S_1 is the nominal section width according to UN Regulation No. 30 except for the sizes listed in Annex V of UN Regulation No. 30 where it is the tyre section width listed therein.

2.1.6. "*Tread-wear indicators*": see definition in UN Regulation No. 30.

2.1.7. "*Centre line*" means the line dividing the overall width of the tyre in two equal parts.

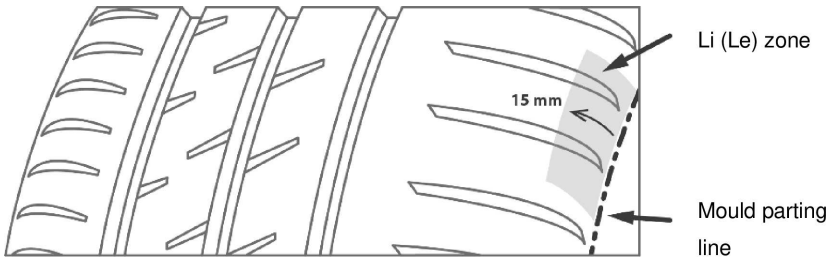
2.1.8. "*Central zone*" means the area on the tread width defined by the ¾ (75%) of the reference tread width (*C*) symmetrically measured from the centre line (see Figure 4).

2.1.9. "*Shoulder zone*" means the area on both sides of the tread outside of the central zone.

2.1.10. "*Mould parting line*" means the border circumference in which mould tread pattern segments connects with mould sidewall plates. If no mould parting line is visible on the tyre, a virtual mould parting line shall be considered as the circumferential line in the equivalent position at the end of the shoulder grooves (see Figure 1).

2.1.11. "*Tread pattern limit points Li and Le*" *means the* points located on the tyre profile between mould parting line and hypothetical point up to 15 mm on the tyre profile towards centre line (see Figure 1).

Figure 1



2.1.12. "*Buffing*" is all the processes of removing material from the tread to prepare the tyre in worn state for following the procedure in paragraph 2.2.1.

2.1.13. "*Reference tyre in worn state*" or "*Reference tyre set in worn state*" means a tyre or a tyre set of Standard Reference Test Tyres moulded SRTT16 worn.

2.2. Theoretical target profile of a tyre at worn state

The theoretical target profile is the profile curve of the tyre in worn state, as described in paragraph 2.2.1.2.2.

2.2.1. Preparation of class C1 tyres in worn state

The following paragraphs outline the preparation of worn tyres of class C1 by removal of a predetermined amount of tread rubber (for example cutting, grinding, surface finish) for subsequent wet grip index testing.

2.2.1.1. Apparatus

2.2.1.1.1. *Tread Depth Gauge.*

Any mechanical, optical, or electronic device capable of measuring groove (void) depth can be used. The resolution of the gauge shall be at least 0.02 mm. The accuracy of the gauge shall be to within ±0.04 mm.

2.2.1.1.2. *Tyre Tread Removal Machine,* with equipment to remove tread rubber in a predetermined manner. Specifically, the equipment shall ensure a buffing accuracy and precision on the final groove depth as required in the paragraph 2.2.1.2.4.1.

2.2.1.2. Procedure

Choose 4 positions approximately equally spaced around the circumference.

Figure 2



At each of the four positions, choose measurement points in the transversal direction:

☐ In the central zone pursuant to the procedure described in paragraph 2.2.1.2.1. and

☐ In each shoulder zone at least one measurement point.

2.2.1.2.1. *Choice of the control measurement points of the central zone*

To control the conformity of the preparation process (see paragraph 2.2.1.2.3.), choose *n* measurement points in the central zone, in the transversal direction (see Figure 3)

☐ The number of measurement points *n* shall be greater than or equal to 4; */

☐ 1 measurement point in each principal groove;

☐ The other measurement points shall be located in non-principal grooves:

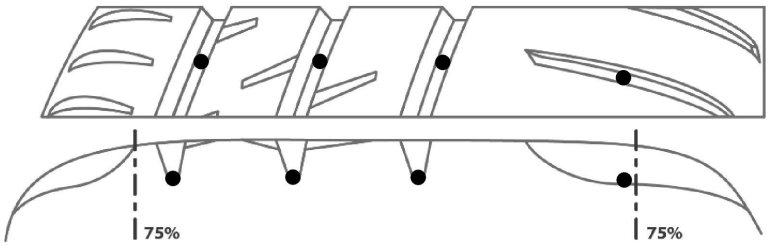
o At the maximum groove depth in the corresponding groove/zone;

o In order to have the most regular distribution of the *n* points.

*/ In case a tyre tread pattern does not allow the measurement at 4 points in the central zone, the groove depth may be measured at 3 measurement points. In case that 3 measurement points in transversal direction are not available, the number and position of the measurement points shall be agreed with the Type Approval Authority.

Measurement points in the principal grooves shall be positioned at locations with full groove depth, for example, avoiding rubber ridges, tie bars, treadwear indicators and other elevated elements.

Figure 3

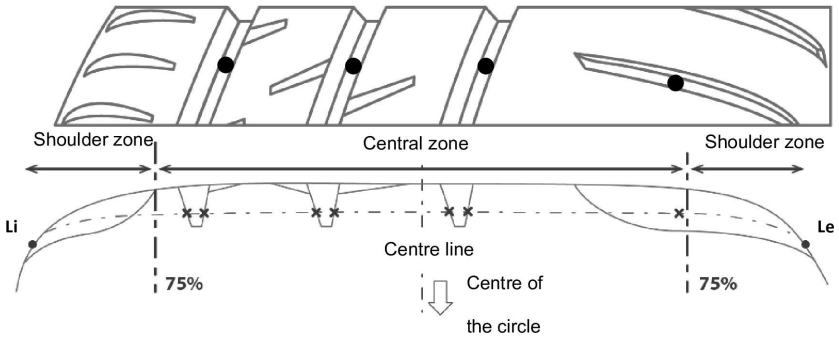


2.2.1.2.2. Description of theoretical worn target profile

Central zone: curve built on a circle with its centre located on the radial axle passing through the centre line and its radius built on a fit on all the points located at 2 mm height on all the control points as described in paragraph 2.2.1.2.1. Alternatively, depending of the specificity of the tread pattern geometry, the fitting curve can be the offset of the original tyre profile.

Shoulder zone: edges of the artificial worn profile in the central part of the tread are connected with Le and Li points. Regularity of the whole artificial worn tyre profile (on the surface of the central zone to the shoulders) shall be assured (for example by an arc of circumference or another curve).

Figure 4



2.2.1.2.3. Preparation of the worn tyre.

Inspect the tyre to determine that there are no tread defects that would affect the finished tyre. If such conditions are noted, do not use the tyre for this procedure.

Depending on the worn tyre preparation processing technique, the removing of the rubber can be managed by directly targeting the worn tyre target profile, or by a manual regular controlling of the rubber removal, or other means.

2.2.1.2.4. Validation of the prepared tyre

2.2.1.2.4.1. Validation of tread depths

At the end of the preparation process, measure the groove depth at the measurement points defined in paragraph 2.2.1.2.1.

For all the measurement points defined in the central zone:

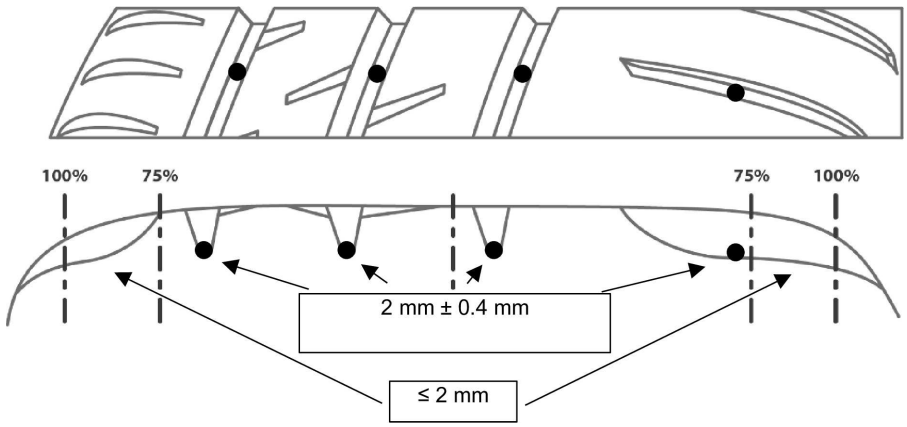
☐ The final groove depth at each individual measurement point of the central zone shall be 2 mm ± 0.4 mm

☐ The average groove depth over all measurement points in the central zone shall be 2 mm ± 0.2 mm

For each measurement point defined in the shoulder zone:

☐ The final groove depth in the shoulder zone shall not be greater than 2 mm.

Figure 5



If one of the above conditions is not met, another candidate tyre shall be prepared.

2.2.1.2.4.1.1. The rim width shall be one specified by a recognized tyre and rim standards organization as listed in Appendix 4 to Annex 6 to this Regulation. The rim width code shall not differ by more than 0.5 from the measuring rim width code.

2.2.1.2.4.1.2. The inflation pressure for the tread depth measurement shall be between 180 kPa and 220 kPa.

2.2.1.2.4.2. Validation of the surface of the worn tyre

The arithmetical mean height of the absolute values of the roughness profile, as defined in ISO 21920-2:2021, of the final surface shall be determined at 3 measurement points in the transversal direction approximately equally spaced on the prepared surface, at 4 circumferential positions equally spaced.

The average of the 3 arithmetical mean height of the absolute values of the roughness profile of the final surface shall not exceed 20 μm.

If the above condition is not met, another candidate tyre shall be prepared.

2.3. General test conditions

2.3.1. Track characteristics

The test track shall have the following characteristics:

2.3.1.1. The surface shall have a dense asphalt surface with a uniform gradient of not more than 2 per cent in both longitudinal and lateral directions and shall not deviate more than 6 mm when tested with a 3 m straight edge.

2.3.1.2. The surface shall have a pavement of uniform age, composition, and wear. The test surface shall be free of loose material and foreign deposits.

2.3.1.3. The maximum chipping size shall be 10 mm (tolerances permitted from 8 mm to 13 mm).

2.3.1.4. The average macro texture depth as measured in accordance with ASTM E965-96 (Reapproved 2006) by a sand patch shall be (0.7 ± 0.3) mm. In case the vehicle method is used, the average macro texture depth shall be determined in both lanes where the tyres are going to brake.

2.3.1.5. The wetted frictional properties of the surface shall be measured using the Standard Reference Test Tyre moulded SRTT16 worn either with the method described in paragraph 2.3.2.1. of this Annex in case the vehicle method (according to paragraph 2.4.1. below) is used, or with the method described in paragraph 2.3.2.2. in this Annex in case the trailer (or tyre test vehicle) method is used.

2.3.2. Methods to measure the wetted frictional properties of the surface

2.3.2.1. Using the procedure described in paragraph 2.4.1. of this Annex, perform two braking tests of the reference tyre, each consisting of at least six (6) valid test runs in the same direction on aligned segments of the track. The braking tests shall cover the entire potential braking area, including where the texture depth was measured.

Evaluate the braking tests as described in paragraphs 2.4.1.1.1. and 2.4.1.1.2. of this Annex. If the coefficient of variation of one braking test CV_{BFC} exceeds 4 per cent, dismiss the results and repeat the braking tests.

For each braking test, the arithmetic mean $\overline{BFC_{ave}}$ of the average Braking Force Coefficients shall be corrected for effects of temperature as follows:

$$BFC_{ave,corr} = \overline{BFC_{ave}} + a \bullet (\vartheta - \vartheta_0)$$

where

ϑ is the wetted surface temperature in degrees Celsius,

$a = 0.002\ °C^{-1}$ and $\vartheta_0 = 20\ °C$.

For each braking test, the temperature-corrected average Braking Force Coefficient ($BFC_{ave,corr}$) shall be not less than 0.4 and not greater than.0.65

The arithmetic means of the temperature-corrected average Braking Force Coefficients of the two braking tests shall not differ by more than 10 per cent of the average of the two values:

$$CVal(BFC_{ave,corr}) = 2 \bullet \left| \frac{BFC_{ave,corr,1} - BFC_{ave,corr,2}}{BFC_{ave,corr,1} + BFC_{ave,corr,2}} \right| \leq 10\ \%$$

2.3.2.2. Using the procedure described in paragraph 2.4.2. of this Annex, perform in the same area where the average macro texture depth was measured one braking test of the reference tyre, consisting of at least six (6) test runs in the same direction.

Evaluate the braking test as described in paragraphs 2.4.2.1.1. and 2.4.2.1.2. of this Annex. If the coefficient of variation CV_{μ} exceeds 4 per cent, dismiss the results and repeat the braking test.

The arithmetic mean ($\overline{\mu_{peak}}$) of the measured peak braking force coefficients shall be corrected for effects of temperature as follows:

$$\mu_{peak,corr} = \overline{\mu_{peak}} + a \bullet (\vartheta - \vartheta_0)$$

Where

ϑ is the wetted road surface temperature in degrees Celsius

$a = 0.002\ °C^{-1}$ and $\vartheta_0 = 20\ °C$.

The temperature corrected average peak braking force coefficient ($\mu_{peak,corr}$) shall be not less than 0.45 and not greater than 0.80.

2.3.3. Atmospheric conditions

The wind conditions shall not interfere with wetting of the surface (wind-shields are allowed).

The wetted surface temperature and the ambient temperature shall be between:

Category of use		Wetted surface temperature	Ambient temperature
Normal tyre		12 °C – 35 °C	12 °C – 40 °C
Snow tyre		5 °C – 35 °C	5 °C – 40 °C
	Snow tyre that is classified as tyre for use in severe snow conditions	5 °C – 20 °C	5 °C – 20 °C
Special use tyre		5 °C – 35 °C	5 °C – 40 °C
	Special use tyre that is classified as tyre for use in severe snow conditions	5 °C – 20 °C	5 °C – 20 °C

Moreover, the wetted surface temperature shall not vary during the test by more than 10 °C.

The ambient temperature shall remain close to the wetted surface temperature; the difference between the ambient and the wetted surface temperatures shall be less than 10 °C.

2.3.4. Replacement of reference tyres

When irregular wear or damage results from tests, or when wear or aging influences the test results, the use of the reference tyre shall be discontinued.

2.4. Testing methods for measuring the adhesion on wet surfaces

For the calculation of the wet grip index (G_B) of a candidate tyre in worn state, the wet grip braking performance of the candidate tyre is compared to the wet grip braking performance of the reference tyre on a vehicle travelling straight ahead on a wet, paved surface. It is measured with one of the following methods:

(a) Vehicle method consisting of testing a set of tyres mounted on an instrumented passenger car;

(b) Testing method using a trailer towed by a vehicle or a tyre test vehicle, equipped with the test tyre(s).

2.4.1. Testing method (a) using an instrumented passenger car

All the provisions specified in Annex 5, Part (A), paragraph 4.1. "Testing method (a) using an instrumented passenger car" and its subparagraphs apply with the exception of paragraph 4.1.6. "Processing of measurement results". The paragraph 2.4.1.1. of this Annex applies instead.

2.4.1.1. Processing of measurement results

2.4.1.1.1. Calculation of the average braking force coefficient

All the provisions specified in Annex 5, Part (A), paragraph 4.1.6.1. apply.

2.4.1.1.2. Validation of results

The coefficient of variation CV_{BFC} is calculated as follows:

$$CV_{BFC} = 100\% \bullet \frac{\sigma_{BFC}}{\overline{BFC_{ave}}}$$

where

$\sigma_{BFC} = \sqrt{\frac{1}{N-1}\Sigma_{j=1}^{N}(BFC_{ave,j} - \overline{BFC_{ave}})^2}$ denotes the corrected sample standard deviation and

$\overline{BFC_{ave}}$ the arithmetic mean of the average braking force coefficients $BFC_{ave,j}$ of N test runs.

For the reference tyre:

(a) The coefficient of variation CV_{BFC} of the initial and the final braking test of the reference tyre within one test cycle shall be less than or equal to 4 per cent.

(b) The arithmetic means of the average braking force coefficients of the initial and the final braking test shall not differ by more than [5] per cent of the average of the two values:

$$CVal(BFC_{ave}) = 100\% \bullet 2 \bullet \left| \frac{\overline{BFC_{ave}}(R_i) - \overline{BFC_{ave}}(R_f)}{\overline{BFC_{ave}}(R_i) + \overline{BFC_{ave}}(R_f)} \right| \leq [5]\%$$

where

$\overline{BFC_{ave}}(R_i)$ and $\overline{BFC_{ave}}(R_f)$ are the arithmetic means of the average braking force coefficients respectively in the initial and final braking tests of the reference tyre within a test cycle.

(c) The temperature-corrected average braking force coefficients ($BFC_{ave,corr}$, see paragraph 2.3.2.1. of this Annex) as calculated from the initial and from the final braking tests of the reference tyre within a test cycle shall be not less than 0.40 and not greater than 0.65.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyres (T):

The coefficient of variation CV_{BFC} is calculated for each candidate tyre set. If one coefficient of variation is higher than 4 per cent, the data shall be discarded and the braking test repeated for that candidate tyre set.

2.4.1.1.3. Calculation of adjusted average braking force coefficient

All the provisions specified in Annex 5, Part (A), paragraph 4.1.6.3. apply.

2.4.1.1.4. Calculation of the wet grip index of the candidate tyre

The wet grip index $G_B(T_n)$ of the candidate tyre T_n (n = 1, 2 or 3) is calculated as follows:

$$G_B(T_n) = K_{vehicle} \bullet \{\overline{BFC_{ave}}(T_n) - [a \bullet \Delta BFC(R) + b \bullet \Delta\vartheta + c \bullet (\Delta\vartheta)^2 + d \bullet \Delta MTD]\}$$

where:

$\overline{BFC_{ave}}(T_n)$ is the arithmetic mean of the average braking force coefficients of the candidate tyre T_n within a braking test;

$$\Delta BFC(R) = BFC_{adj}(R) - BFC(R_0)$$

$BFC_{adj}(R)$ is the adjusted average braking force coefficient in accordance with Table 1 of Annex 5;

$BFC(R_0)$ = 0.52 is fixed as the braking force coefficient for the reference tyre in the reference conditions;

$$\Delta\vartheta = \vartheta - \vartheta_0$$

ϑ is the measured wet surface temperature in degrees Celsius when the candidate tyre T_n is tested;

ϑ_0 is the wetted surface reference temperature for the candidate tyre according to its category of use as listed in Table 2;

$$\Delta MTD = MTD - MTD_0$$

MTD = is the measured macro texture depth in mm of the track (see paragraph 3.1.4. of this Annex);

MTD_0 = 0.8 mm is the macro texture depth of the reference track;

$K_{vehicle}$ = 1.95 is a factor to grant consistency between previous calculation of the wet grip index and this one, and to ensure convergence between vehicle and trailer method and

coefficients *a*, *b*, *c* and *d* are given in Table 2.

Table 2

Category of use		ϑ_0 (°C)	a	b ($°C^{-1}$)	c ($°C^{-2}$)	d (mm^{-1})
Normal tyre		20	+0,90996	− 0,00179	− 0,00013	− 0,10313
Snow tyre		15	+0,81045	− 0,00004	− 0,00019	− 0,05093
	Snow tyre that is classified as tyre for use in severe snow conditions	10	+0,71094	+0,00172	− 0,00025	+0,00127
Special use tyre		15	+0,81045	− 0,00004	− 0,00019	− 0,05093
	Special use tyre that is classified as tyre for use in severe snow conditions	10	+0,71094	+0,00172	− 0,00025	+0,00127

2.4.2. Testing method (b) using a trailer towed by a vehicle or a tyre test vehicle

All the provisions specified in Annex 5, Part (A), paragraph 4.2. "Testing method (b) using a trailer towed by a vehicle or a tyre test vehicle" and its subparagraphs apply with the exception of paragraph 4.2.8. "Processing of measurement results". The paragraph 2.4.2.1. of this Annex applies instead.

2.4.2.1. Processing of measurement results

2.4.2.1.1. Calculation of the peak braking force coefficient

All the provisions specified in Annex 5, Part (A), paragraph 4.2.8.1. apply.

2.4.2.1.2. Validation of results

The μ_{peak} coefficient of variation CV_{μ} is calculated as follows:

$$CV_{\mu} = 100\% \bullet \frac{\sigma_{\mu}}{\overline{\mu_{peak}}}$$

where

$\sigma_{\mu} = \sqrt{\frac{1}{N-1}\Sigma_{j=1}^{N}(\mu_{peak,j} - \overline{\mu_{peak}})^2}$ denotes the corrected sample standard deviation and

$\overline{\mu_{peak}}$ the arithmetic mean of the peak braking force coefficients ($\mu_{peak,j}$) of N test runs.

For the reference tyre (R):

(a) The coefficients of variation CV_{μ} of the initial and the final braking tests of the reference tyre within one test cycle shall be less than or equal to 4 per cent;

(b) The arithmetic mean of the peak braking force coefficients of initial and the final braking test of the reference tyre within one test cycle shall not differ by more than 5 per cent of the average of the two values:

$$CVal(\mu_{peak}) = 100\% \bullet 2 \bullet \left| \frac{\overline{\mu_{peak}}(R_i) - \overline{\mu_{peak}}(R_f)}{\overline{\mu_{peak}}(R_i) + \overline{\mu_{peak}}(R_f)} \right| \leq 5\%$$

where

$\overline{\mu_{peak}}(R_i)$ and $\overline{\mu_{peak}}(R_f)$ are the arithmetic means of the peak braking force coefficients respectively in the initial and final braking tests of the reference tyre within a test cycle;

(c) The temperature-corrected average peak braking force coefficients ($\mu_{peak,corr}$, see paragraph 2.3.2.2. of this Annex) as calculated from the initial and from the final braking test of the reference tyre within a test cycle shall be not less than 0.45 and not greater than 0.80.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyre(s) (T_n):

The coefficient of variation of the peak braking force coefficient CV_{μ} is calculated for each candidate tyre. If one coefficient of variation is greater than 5 per cent, the data shall be discarded and the braking test repeated for this candidate tyre.

2.4.2.1.3. Calculation of the adjusted average peak braking force coefficient of the reference tyre

All the provisions specified in Annex 5, Part (A), paragraph 4.2.8.3. apply.

2.4.2.1.4. Calculation of the wet grip index of the candidate tyre

The wet grip index $G_B(T_n)$ of the candidate tyre T_n (n = 1, 2, 3) is calculated as follows:

$$G_B(Tn) = K_{trailer} \bullet \{\overline{\mu_{peak}}(Tn) - [a \bullet \Delta\mu_{peak}(R) + b \bullet \Delta\vartheta + c \bullet (\Delta\vartheta)^2 + d \bullet \Delta MTD]\}$$

where:

$\overline{\mu_{peak}}(T_n)$ is the arithmetic mean of the peak braking force coefficients of the candidate tyre T_n within a braking test;

$$\Delta\mu_{peak}(R) = \mu_{peak,adj}(R) - \mu_{peak}(R_0)$$

$\mu_{peak,adj}(R)$ is the adjusted peak braking force coefficient in accordance with Table 3 of Annex 5;

$\mu_{peak}(R_0)$= 0.71 is fixed as the peak braking force coefficient for the reference tyre in the reference conditions;

$$\Delta\vartheta = \vartheta - \vartheta_0$$

ϑ is the measured wet surface temperature in degrees Celsius when the candidate tyre T_n is tested;

ϑ_0 is the wetted surface reference temperature for the candidate tyre according to its sidewall marking as listed in Table 4;

$$\Delta MTD = MTD - MTD_0$$

MTD = is the measured macro texture depth of the track

MTD_0 = 0.8 mm is fixed as the macro texture depth of the reference track;

$K_{trailer}$ = 1.50 is a factor to grant consistency between previous calculation of the wet grip index and this one, and to ensure convergence between vehicle and trailer method and

coefficients *a*, *b*, *c* and *d* are given in Table 4.

Table 4

Category of use		ϑ_0 (°C)	a	b ($°C^{-1}$)	c ($°C^{-2}$)	d (mm^{-1})
Normal tyre		20	+0,99655	− 0,00124	+0,00041	+0,06876
Snow tyre		15	+0,94572	− 0,00032	− 0,00020	+0,08047
	Snow tyre that is classified as tyre for use in severe snow conditions	10	+0,89488	+0,00061	− 0,00080	+0,09217
Special use tyre		15	+0,94572	− 0,00032	− 0,00020	+0,08047
	Special use tyre that is classified as tyre for use in severe snow conditions	10	+0,89488	+0,00061	− 0,00080	+0,09217

3. Evaluation of the adhesion of tyres of classes C2 and C3

Wet grip index evaluation of the tyre in worn state

Principle

Two steps:

(a) The wet grip index *G* of the tyre in new state is evaluated following the provisions specified in Annex 5, Part (B), "Classes C2 and C3 tyres" and its subparagraphs.

(b) The wet grip index G_B in worn state of tyres of classes C2 and C3 is evaluated using the following formulae:

$$G_B(C2) = K_{worn}(C2) \bullet G(C2)$$

$$G_B(C3) = K_{worn}(C3) \bullet G(C3)$$

K_{worn} is the performance drop factor between the wet grip in new state and in worn state:

K_{worn} (C2) = 0.87

K_{worn} (C3) = 0.83

Annex 9 – Appendix 1

Worn tyre preparation report example

Date of buffing	
Manufacturer	
Brand	
Trade description/commercial name	
Size	
Service description	
Rim width	
Inflation pressure (kPa)	
Week of manufacture	
Tyre identification code	

Groove depth measurement

Groove depth Central zone: (2.0 ± 0.4) mm Shoulder zone: ≤ 2 mm		in central zone (yes/no)	Circumferential locations			
			1	2	3	4
Transversal locations	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					

	Values
Average groove depth in central zone (mm) Central zone: (2.0 ± 0.2) mm	

Roughness measurement

Arithmetical mean height of the absolute values of the roughness profile (μm)		Sections			
		1	2	3	4
Trans. Loc.	1 (right)				
	2 (centre)				
	3 (left)				
Average					

Annex 9 – Appendix 2

Test reports examples of wet grip index for tyres in worn state

Example 1: Test report of wet grip index for tyres in worn state using trailer or tyre test vehicle method

Test report number:		Test date:		
Track:			Minimum:	Maximum:
Texture depth (mm):		Wetted surface temp. (°C):		
$\mu_{peak,corr}$:		Ambient temp (°C):		
Water depth (mm):				
Speed (km/h):				

No.	1	2	>3	4	5
Brand					
Pattern/trade description	SRTT…				SRTT…
Size					
Service description					
Reference (test) inflation pressure (kPa)					

No.		1	2	>3	4	5
Tyre identification						
M+S marking (Y/N)						
3PMSF marking (Y/N)						
Rim						
Load (kg)						
Pressure (kPa)						
μ_{peak}	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
$\overline{\mu_{peak}}$						
Standard deviation, σ_{μ}						
$CV_{\mu} \leq 4$ %						
$CVal(\mu_{peak}) \leq 5$ %						
$\mu_{peak,corr}(R)$						
$\mu_{peak,adj}(R)$						
Wet grip index						
Wetted surface temp. (°C)						
Ambient temp. (°C)						
Remarks						

Example 2: Test report of wet grip index for tyres in worn state using vehicle method

Test report number:		Test date:					
Track:			Minimum:	Maximum:	Vehicle		
Texture depth (mm):		Wetted surface temp. (°C):			Brand:		
$BFC_{ave,corr,1}$:		Ambient temp (°C):			Model:		
$BFC_{ave,corr,2}$:					Type:		
$CVal(BFC_{ave,corr})$:					Year of registration:		
Water depth (mm):					Maximum axle load:	Front	Rear
Initial speed (km/h):		Final speed (km/h):					

No.	1		2		3		4		5	
Brand										
Pattern/trade description	SRTT…								SRTT…	
Size										
Service description										
Reference (test) inflation pressure (kPa)										
Tyre identification										
M+S marking (Y/N)										
3PMSF marking (Y/N)										
Rim										
Front axle pressure (kPa)	left:	right:	left:	right:	left:	right:	left:	right:	left:	right:
Rear axle pressure (kPa)	left:	right:	left:	right:	left:	right:	left:	right:	left:	right:

No.		1		2		3		4		5	
Front axle load (kg)		left:	right:	left:	right:	left:	right:	left:	right:	left:	right:
Rear axle load (kg)		left:	right:	left:	right:	left:	right:	left:	right:	left:	right:
		Braking distance (m)	BFC_i	*Braking distance (m)*	BFC_i	*Braking distance (m)*	BFC_i	*Braking distance (m)*	BFC_i	*Braking distance (m)*	BFC_i
Measurement	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
$\overline{BFC_{ave}}$											
Standard deviation, σ_{BFC}											
$CV_{BFC} \leq 4$ %											
$CVal(BFC_{ave}) \leq 5$ %											
$BFC_{ave,corr}(R)$											
$BFC_{adj}(R)$											
Wet grip index											
Wetted surface temp. (°C)											
Ambient temp. (°C)											
Remarks											

ANNEX 10

Procedure for determining the abrasion performance of tyres of class C1

Introduction

For the calculation of the tyre abrasion index of a candidate tyre, the abrasion level of the candidate tyre is compared to the abrasion level of a standard reference test tyre. It is measured with one of the following test methods:

(a) vehicle test method on public open roads;

(b) indoor drum test method.

1. Test method (a) using vehicle on public open roads

1.1. Scope

This method applies to C1 tyres in scope of this regulation except ice grip tyres and tyres having a nominal rim diameter code ≤ 13.

1.2. Definitions

In addition to relevant definitions set at point 2 of this Regulation the following apply.

1.2.1. *"Loop"* means the section of the circuit having the same starting and ending point. If the same loop is run clockwise and counterclockwise it shall be considered as 2 loops.

1.2.2. *"Circuit"* identifies the roads which will be used for the abrasion test. The circuit may consist of one or several loops, which can be run in any order.

1.2.3. *"Shift"* means the period of time required to run the circuit (including break time, rotation time between vehicle in convoy or drive in vehicle).

1.2.4. *"Total distance"* is the total distance ran by a tyre during the test.

1.2.5. *"Electric machine"* identifies the energy converter transforming between electrical and mechanical energy.

1.2.6. *"Category of propulsion energy converter"* means (i) an internal combustion engine, (ii) an electric machine or (iii) fuel cell.

1.2.7. *"Hybrid electric vehicle (HEV)"* is a Hybrid vehicle where one of the propulsion energy converters is an electric machine.

1.2.8. *"Hybrid vehicle"* is a vehicle equipped with a powertrain containing at least two different categories of propulsion energy converters and at least two different categories of propulsion energy storage systems.

1.2.9. *"Not off-vehicle charging hybrid electric vehicle (NOVC-HEV)"* is a hybrid electric vehicle that cannot be charged from an external source.

1.2.10. *"Off-vehicle charging hybrid electric vehicle (OVC-HEV)"* is a Hybrid electric vehicle that can be charged from an external source.

1.2.11. *"Pure electric vehicle (PEV)"* is a vehicle equipped with a powertrain containing exclusively electric machines as propulsion energy converters and exclusively rechargeable electric energy storage systems (REESS) as propulsion energy storage systems.

1.2.12. *"Pure internal combustion engine (ICE) vehicle"* is a vehicle where all propulsion energy converters are internal combustion engines.

1.2.13. *"Traction REESS"* means an electric energy storage system that is rechargeable and that provides electric energy for electric propulsion.

1.2.14. *"FWD (Front Wheel Drive) vehicle"* means a vehicle where only the front axle delivers traction torque.

1.2.15. *"RWD (Rear Wheel Drive) vehicle"* means a vehicle where only the rear axle delivers traction torque.

1.2.16. *"4WD (4 Wheel Drive) vehicle"* means a vehicle where the axle traction torque for one axle can be switched off by the driver.

1.2.17. *"AWD (All Wheel Drive) vehicle"* means a vehicle with permanent or vehicle controlled 4 wheels drive.

1.2.18. *"Reference vehicle"* identifies the vehicle that will be fitted with the reference tyres.

1.2.19. *"Candidate vehicle"* identifies the vehicle that will be fitted with the candidate tyres.

1.2.20. *"Vehicle f2 coefficient"* (measured in $N/(km/h)^2$) is the second order road load coefficient according to UN Regulation No. 154. It is provided at reference conditions.

1.2.21. *"Longitudinal acceleration"* (measured in m/s^2) is the acceleration in the direction of vehicle movement. Longitudinal acceleration has a positive sign for speed increase and a negative sign for speed decrease (e.g. braking).

1.2.22. *"Lateral acceleration"* (measured in m/s^2) is the acceleration perpendicular to the direction of vehicle movement. Lateral acceleration has a positive sign when turning left in the direction of the vehicle movement. Lateral acceleration has a negative sign when turning right in the direction of the vehicle movement.

1.2.23. *"Test tyre"* indicates either candidate tyres or reference tyres.

1.2.24. *"Candidate tyre"* means a tyre whose abrasion performance is evaluated relative to that of a reference tyre.

1.2.25. *"Reference tyre"* means the tyre which will be used in each convoy as a reference for the evaluation of the abrasion performance of the candidate tyre, according to the following table:

		Reference tyre	
Candidate tyre		SRTT17S	SRTT17W
Normal tyre		X	
Snow tyre			X
	Snow tyre that is classified as tyre for use in severe snow conditions		X

		Reference tyre	
Candidate tyre		SRTT17S	SRTT17W
Special use tyre		X	
	"M+S" or "M.S" or "M&S"		X
	Special use tyre that is classified as tyre for use in severe snow conditions		X

1.3 Symbols and abbreviated terms

Symbol	Unit	Designation
AICT	No dimension	Abrasion index of the candidate tyre
ALC	mg/km/t	Abrasion level of candidate tyre at test conditions
ALRT	mg/km/t	Abrasion level of reference tyre at test conditions
ARC	mg/km	Abrasion rate of candidate tyre at test conditions
ARR	mg/km	Abrasion rate of reference tyre at test conditions
D_{Ci}	km	Total distance run by candidate vehicle during the test
D_{Ri}	km	Total distance run by reference vehicle during the test
$MCTF_i$	g	Candidate tyre final mass of tyre *i*
$MCTS_i$	g	Candidate tyre initial mass of tyre *i*
$MRTF_i$	g	Reference tyre final mass of tyre *i*
$MRTS_i$	g	Reference tyre initial mass of tyre *i*
O_S	mg/km/t	Offset of the regression lines of the reference tyre abrasion level of SRTT17S
O_W	mg/km/t	Offset of the regression lines of the reference tyre abrasion level of SRTT17W
Q_{Ci}	kg	Test load for each candidate tyre
Q_{Ri}	kg	Test load for each reference tyre
S_S	mg/km/t/°C	Sensitivity of *SRTT17S* to temperature variation
S_W	mg/km/t/°C	Sensitivity of *SRTT17W* to temperature variation
T_i	°C	Average temperature of the test
$\overline{T}$	°C	Average temperature of the n tests

1.4. Instrumentation.

1.4.1. Instruments for tyre mass measurement.

The weight scale shall be able to measure the tyre mass with an accuracy of ± 2 g.

1.4.2. Instruments for alignment and camber measurement on vehicle

The device shall have an accuracy of ± 0.033 degrees.

1.4.3. Instruments for vehicle mass measurement per position.

The weight scale shall be able to measure the load on each tyre with an accuracy of ± 0.1 per cent.

1.4.4. Instruments for acceleration, distance, and speed measurements.

During the test, a continuous evaluation of speed, lateral, and longitudinal acceleration shall be done, with a minimum and recommended sampling rate of 10 Hz. GNSS (Global Navigation Satellite System as defined by ISO 24245:2023) measurement associated with numerical treatment of the positions shall be used. See numerical treatment for GNSS (Global Navigation Satellite System) data in Appendix 1 to Annex 10 of this Regulation.

The distance ran by the tyre shall equal the GNSS reported distance plus the distance ran without a GNSS signal, unless this distance is estimated by the GNSS itself.

Accelerometers shall not be used.

1.4.5. Tyre pressure measurement device.

The device shall have an accuracy of ± 3 kPa.

1.4.6. Instruments for weather (rain, snow, ice) measurement.

For rain, test drivers shall report mileage with wipers in function (actually wiping the windshield) for each shift.

For snow/ice, test drivers shall report mileage driven with snow or ice on the road for each shift.

1.4.7. Instruments for temperature measurement.

The vehicle external thermometer may be used. Data shall be recorded with time and location on paper or file. Any thermometer positioned to measure external air temperature is acceptable as well. The thermometer shall have a measurement accuracy of ± 1 °C. A continuous measurement device recording the temperature is acceptable as well provided it fulfils the measurement accuracy described above.

Initial and final measurement shall be done using a calibrated thermometer.

1.4.8. Instruments for tyre and wheel assembly mass measurement

The weight scale shall be able to measure the tyre mass with an accuracy of ± 2 g.

1.5. Tyre, tyre and wheel assembly, and vehicle measurement procedure

1.5.1. Tyre mass measurement

The tyre shall be cleaned and dried before the mass measurement, with device or product not removing any rubber from the tyre (e.g. water based non-abrasive cleaner). Any visible stone shall be removed from the pattern before mass measurement. The measurement shall be repeated 3 times and averaged.

1.5.2. Tyre and wheel assembly mass measurement

The tyre assembly shall be cleaned and dried before the mass measurement, with device or product not removing any rubber from the tyre (e.g. water based non-abrasive cleaner). Any visible stone shall be removed from the pattern before mass measurement, without air pressure, and without valve core.

The mass measurement shall be performed after checking that the balancing masses are all present on the assembly.

1.5.3. Vehicle mass measurement procedure

The vehicle shall be cleaned and dried before measurement, with full fuel tank (ICE vehicle), test ballast as described in paragraph 1.6. of this Annex, equipped with the tyres to be tested, and wheels used for the test with drivers' average weight (i.e. 75 kg). Load Q on each wheel shall be measured.

1.5.4. Wheel alignment measurement procedure

The wheel alignments shall be measured, with full fuel tank (ICE vehicle), test ballast as described in paragraph 1.6. of this Annex, equipped with the tyres to be tested, and wheels used for the test with drivers' average weight (i.e. 75 kg).

1.6. Vehicle requirements

1.6.1. General requirements

Alignments setting shall be performed as following:

(a) Measure and record the alignment values with vehicles in loaded conditions as explained in 1.5.4;

(b) The values measured with loaded conditions will be monitored during the test and will serve as the reference values to respect during the tests.

Alignments (TOE and camber) on both axles of reference vehicle and of each candidate vehicle shall be checked at least:

(c) At the beginning of the test. The alignment shall take place maximum at 50 km of distance run before starting the test;

(d) Optionally at half distance;

(e) In case of an impact that may affect the alignment (e.g. curbstone contact, etc);

(f) At the end of the test. The alignment shall take place maximum at 50 km of distance run after finishing the test;

(g) Any additional distance to reach the geometry measurement facility shall not be driven with reference or candidate tyres.

At the end of the test, the alignments shall not vary by more than ± 0.15 degrees for toe and ± 0.3 degrees for camber from initial measurement under the same condition.

1.6.2. Acceptable suspension geometry and static adjustment values for FWD vehicles

1.6.2.1. Vehicles used for candidate tyres, loaded condition as described in paragraph 1.5.4.:

(a) Toe IN/OUT angle per wheel on the front axle set to 0 ± 0.1 degrees;

(b) Camber angle per wheel on the front axle set between - 1,2 degrees to 0 degrees;

(c) Toe IN/OUT angle per wheel on the rear axle between 0.05 degrees and 0.15 degrees;

(d) Camber angle per wheel on the rear axle between - 1,9 degrees and - 0,6 degrees.

1.6.2.2. Vehicle used for reference tyres, loaded condition as described in paragraph 1.5.4:

(a) Toe IN/OUT angle per wheel on the front axle set to 0 ± 0.05 degrees;

(b) Camber angle per wheel on the front axle set between - 1,2 degrees to 0 degree;

(c) Toe IN/OUT angle per wheel on the rear axle between 0.05 degrees and 0.15 degrees;

(d) Camber angle per wheel on the rear axle between - 1,9 degrees and - 0,6 degrees;

(e) In addition, the toe IN/OUT in absolute value shall be lower than or equal to the values used in the test vehicles for the front axle.

1.6.3. Acceptable suspension geometry and static adjustment values for RWD vehicles

1.6.3.1. Vehicles used for candidate tyres, loaded condition as described in paragraph 1.5.4.:

(a) Toe IN/OUT angle per wheel on the front axle set to 0 ± 0.1 degrees;

(b) Camber angle on the front axle set to 0 ± 0.1 degrees;

(c) Toe IN/OUT angle per wheel on the rear axle set to 0 ± 0.1 degrees;

(d) Camber angle on the rear axle set to 0 ± 0.1 degrees.

1.6.3.2. Vehicle used for reference tyres loaded condition as described in paragraph 1.5.4.:

(a) Toe IN/OUT angle per wheel on the front axle set 0 ± 0.05 degrees;

(b) Camber angle on the front axle set to 0 ± 0.1 degrees;

(c) Toe IN/OUT angle per wheel on the rear axle set to 0 ± 0.1 degrees;

(d) Camber angle on the rear axle set to 0 ± 0.1 degrees; .

(e) In addition, toe IN/OUT in absolute value shall be lower than or equal to the values used for candidate vehicles for front axle.

1.6.4. Acceptable suspension geometry and static adjustment values for 4WD vehicles

4WD vehicles may be used if only one axle is applied as drive axle. In this case, they are considered as FWD or RWD, depending on the configuration.

1.6.5. Vehicles acceptable suspension and static tuning for AWD vehicles

Vehicle with permanent 4WD shall respect the RWD vehicles settings described in paragraph 1.6.3. of this Annex.

1.6.6. In case no vehicle respects the conditions described in paragraph 1.6.2., 1.6.3., 1.6.4. or 1.6.5., the following process shall be used:

(a) Measurement with at least 4 different vehicles (if 4 vehicles available or all the available vehicles if less than 4) able to fit the candidate tyres must demonstrated that the settings limits cannot be achieved. The vehicles shall be aged of less than two years, and made by 4 different carmakers.

(b) Select vehicles (both reference and candidate vehicles) respecting following criteria:

(i) Front Toe shall respect the previously given tolerances (0° +/- tolerance);

(ii) Front camber angle shall not differ by more than 0.5° between Reference and Candidate vehicle. Reference vehicle shall have a Front Camber lower than or equal to the respective value of the candidate vehicle, in absolute value;

(iii) Rear camber angle shall not differ by more than 0.6° between reference and candidate vehicle. Reference vehicle shall have a rear camber lower than or equal to the respective value of the candidate vehicle, in absolute value;

(iv) Rear Toe angle shall not differ by more than 0.1° between reference and candidate vehicle. Reference vehicle shall have a rear toe lower than or equal to the respective value of the candidate vehicle, in absolute value;

(v) In addition, the following limit shall be respected for candidate vehicles with loaded condition as described in paragraph 1.5.3.:

a. Toe IN/OUT angle per wheel on the front axle set to 0 ± 0.1 degrees;

b. Camber angle on the front axle set between - 1,7 degrees and 0 degree;

c. Toe IN/OUT angle per wheel on the rear axle set between 0.05 degree and 0.3 degrees;

d. Camber angle on the rear axle set between - 2,7 degree and 0.3 degrees.

(vi) In addition, the following limit shall be respected for reference vehicles with loaded condition as described in paragraph 1.5.3.:

a. Toe IN/OUT angle per wheel on the front axle set to 0 ± 0.05 degrees;

b. Camber angle on the front axle set between - 1,7 degrees and 0 degree;

c. Toe IN/OUT angle per wheel on the rear axle set between 0.05 degree and 0.3 degrees;

d. Camber angle on the rear axle set between - 2,7 degree and 0.3 degrees.

1.6.7. Vehicle acceptable propulsion energy convertor

All the propulsion energy convertor types are allowed, as long as they are homogeneous in the convoy. The convoy shall consist of vehicles that belong in the same vehicle type in terms of the vehicles' electrification grade (i.e. ICE or NOVC-HEV or OVC-HEV or PEV).

1.6.8. Vehicle acceptable transmission system

A FWD vehicle shall be used for the tyre size to be tested when available.

If the tyre size can only be fitted on RWD vehicles, a RWD vehicle shall be used, and the reference tyres shall as well be fitted on RWD vehicle.

If the tyre size can only be fitted on all wheels drive vehicles, an all wheels drive vehicle shall be used, and the reference tyre shall as well be fitted on all wheels drive vehicle. If available, vehicle with similar torque distribution shall be used for both reference tyre and candidate tyre. If not available, the default mode shall be used for both reference vehicle and candidate vehicle.

Vehicles featuring automatic or manual transmission systems are allowed in the same convoy.

1.6.9. Vehicle driving mode

If several driving modes are available, the default driving mode, if defined by the vehicle manufacturer, shall be selected.

In the case that no default driving mode is defined by the vehicle manufacturer, the use of a representative driving mode shall be agreed with the responsible authority.

1.6.10. Regenerative braking

The vehicles of the convoy shall have similar regenerative capabilities. This is fulfilled by selecting vehicles of the similar electrification grade (see 1.6.7). If the regenerative braking function of a vehicle can be deactivated, the driver is allowed to do so only if all vehicles in the convoy run under the same regenerative braking conditions.

1.6.11. Vehicle acceptable aerodynamic performances

Aerodynamic performance of the vehicle fitted with reference tyres shall respect the following condition:

The f2 value of the vehicle with reference tyres shall be lower than or equal to 1.2 times the f2 value of the vehicles with candidate tyres.

The provision defined in this paragraph does not apply when the f2 value of the vehicles is not available to the testing facility.

1.6.12. Vehicle acceptable mass (depending on the tyre size and tyre load capacity index)

The total vehicle mass shall allow to load the tyre with a total load of (67 ± 7) per cent of the total nominal tyre load capacity for 4 tyres.

Example of calculation:

Assuming that the reference tyres load index is 94, which corresponds to a maximum load of 670 kg.

The total load nominal load of the 4 reference tyres would then be: 670*4 = 2680 kg.

The loaded vehicle mass shall then be 2 680*67 % = 1 796 kg with a tolerance of 2 680*7 %, which corresponds to ± 188 kg.

Load distribution between front and rear axle shall be as following:

(a) For FWD vehicles

Front axle load: (56 ± 7) per cent of total vehicle load.

Rear axle load: (44 ± 7) per cent of total vehicle load.

(b) For AWD/RWD vehicles

Front axle load: (50 ± 7) per cent of total vehicle load.

Rear axle load: (50 ± 7) per cent of total vehicle load.

Ballasting allowing to reach above loads is authorized, as long as it does not exceed 85 per cent of the vehicle maximum payload. A minimum ballast of 1.5 passengers including driver shall be included.

1.6.13. Circuit, acceleration, and speed requirements

The circuit shall be a closed loop. Vehicles shall return to the departure point without being transported on a car carrier.

1.6.13.1. Circuit minimum length

Circuit shall be made of one or several closed loops. Vehicles shall return to the departure point. The minimum length shall be 300 km of different roads. Vehicle shall not be transported on a car carrier, except in case of vehicle/tyre failure.

1.6.13.2. Driving style distribution

The circuit shall respect the following distribution of acceleration/distance for each one of the represented driving styles:

(a) Roads representative of highway-like driving style:

(i) more than 35 per cent of the total distance;

(ii) The longitudinal acceleration standard deviation shall be in range from 0.10 to 0.45 m/s^2;

(iii) The lateral acceleration standard deviation shall be in range from 0.15 to 1.00 m/s^2.

(b) Roads representative of urban-like driving style:

(i) more than 25 per cent of the total distance;

(ii) The longitudinal acceleration standard deviation shall be in range from 0.45 to 0.90 m/s^2;

(iii) The lateral acceleration standard deviation shall be in range from 0.40 to 1.20 m/s^2.

(c) Roads representative of regional-like driving style corresponds to the data points not lying in one of the clusters defined in (a) and (b) of this paragraph;

(d) In addition, the speed distribution for the circuit shall respect the following conditions:

(i) The speed shall be lower than 60 km/h for at least 10 per cent of the global distance;

(ii) The speed shall be equal to or higher than 60 km/h and lower than 90 km/h for at least 25 per cent of the global distance;

(iii) The speed shall be equal to or higher than 90 km/h for at least 35 per cent of the global distance.

The calculation of the speed distribution shall be carried out using the 10 Hz data recorded on the global distance.

1.6.13.3. Global accelerations level

The following provisions regarding the acceleration standard deviation and maximum values shall apply:

1.6.13.3.1. Standard deviation

(a) Longitudinal acceleration: 0.45 m/s^2 ± 10 per cent;

(b) Lateral acceleration: 0.93 m/s^2 ± 10 per cent.

Longitudinal and lateral accelerations standard deviations during the test shall not deviate by more than 5 per cent from one vehicle to another vehicle of the same convoy.

1.6.13.3.2. Maximum acceleration

(a) Longitudinal acceleration: ± 5 m/s^2 for a distance representing at least 99.98 per cent of the total distance;

(b) Lateral acceleration: ± 5 m/s^2 for a distance representing at least 99.9 per cent of the total distance.

1.6.14. Speed requirements

Speed, with a measurement tolerance of 10 km/h, shall not exceed the applicable legal limits applying in the respective country where the circuit is located. Additionally, the speed shall not exceed the value of 140 km/h. The maximum tolerance in distance travelled (including measuring tolerance of 10 km/h) is 0.5 per cent (40 km in total for 8 000 km driving distance).

1.6.15. Acceleration and speed monitoring during the test

Acceleration and speed shall be constantly monitored during the test for each car in the convoy.

Details regarding acceleration and speed calculation are provided in Appendix 1 of this Annex.

1.6.16. Circuit abrasion level

To be usable for test, the circuit shall respect the following abrasion level specifications for reference tyres:

(a) SRTT17S: the circuit abrasion level at 20 °C shall be in the range from 25 to 75 mg/km/t;

(b) SRTT17W: the circuit abrasion level at 10 °C shall be in the range from 25 to 75 mg/km/t.

If a circuit uses only one of the reference tyres (e.g. only the SRTT17S), only one of the conditions shall be respected, the one for the reference tyre which is used on the circuit.

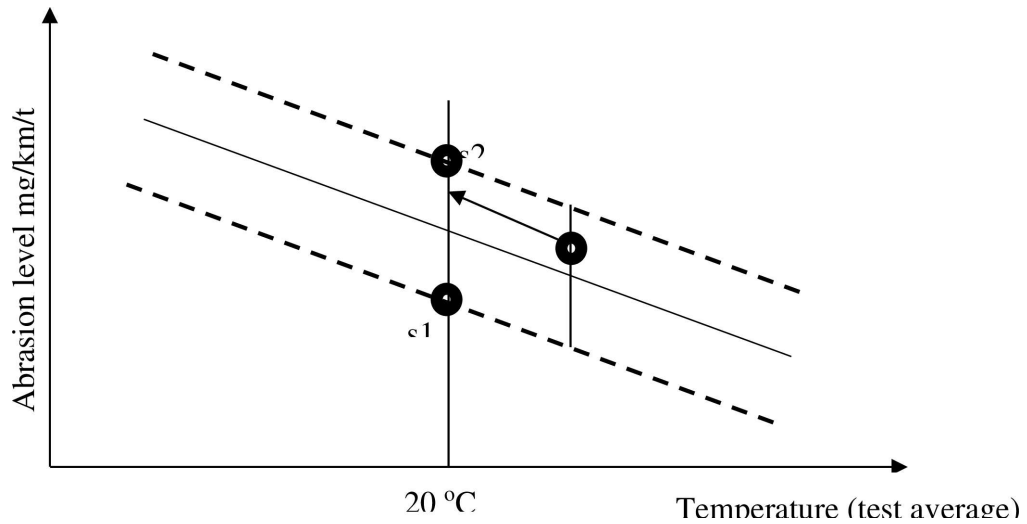


Figure 1: The normalised to 20°C abrasion level of the test shall be within s1 and s2.

The calculation of the circuit abrasion level shall be made according to paragraph 1.6.16.1. of this Annex.

1.6.16.1. The following provisions apply for the measurement of the abrasion level of the reference tyre:

(a) At least one reference tyre (SRTT17S or SRTT17W) shall be selected. The reference tyre shall be measured at least at 3 different temperatures differing from each other by more than 5 °C;

(b) The value of abrasion level for references tyres at 20 °C (SRTT17S) or 10°C (SRTT17W) shall be given by a linear regression;

(c) For SRTT17S, at least one measurement shall be done between 15 and 25 °C;

(d) For SRTT17W, at least one measurement shall be done between 5 and 15 °C.

For each of the (at least) 3 sets of reference tyres tested, the $ALRT_i$ abrasion level in mg/km/t at a temperature T_i is available.

Calculation shall be updated each quarter using the results of all performed tests from the previous 4 quarters, starting one year after the circuit's initial accreditation. Update of slopes and offset at origin may only be performed if the range of temperature covers the provisions of this paragraph.

The sensitivity of SRTT17S and SRTT17W to temperature variation during the test ("S_S" and "S_W") (i.e. the slope of the regression line of the reference tyre abrasion level to the average test temperature) is calculated by means of the following equation:

$$S_S = \frac{\sum_{i=1}^{n}(ALRT_i - \overline{ALRT}) \times (T_i - \overline{T})}{\sum_{i=1}^{n}(T_i - \overline{T})^2} \quad \text{for SRTT17S}$$

$$S_W = \frac{\sum_{i=1}^{n}(ALRT_i - \overline{ALRT}) \times (T_i - \overline{T})}{\sum_{i=1}^{n}(T_i - \overline{T})^2} \quad \text{for SRTT17W}$$

The offsets of the regression lines of the reference tyre abrasion level to the average test temperature during the test are calculated by means of the following equations:

$$O_S = \overline{ALRT} - S_S \bullet \overline{T} \text{ for SRTT17S}$$

$$O_W = \overline{ALRT} - S_W \bullet \overline{T} \text{ for SRTT17W}$$

The circuit abrasion levels at the relevant temperatures are calculated by means of the following equations:

$$R_{ACS} = O_S + S_S \bullet 20 \text{ for SRTT17S}$$

$$R_{ACW} = O_W + S_W \bullet 10 \text{ for SRTT17W}$$

Where:

S is the slope of the regression line of the reference tyre abrasion level to the temperatures during the tests;

$ALRT_i$ is the abrasion level of reference tyre at test conditions in mg/kg/t;

$\overline{ALRT}$ is the average abrasion level of the n reference tyres at three temperatures in mg/kg/t;

T_i is the average temperature of the test in °C;

$\overline{T}$ is the average temperature of the n tests in °C.

n is the number of tests performed.

If the circuit is utilized for both SRTT17S and SRTT17W, the S calculation shall be done for each reference tyre, giving S_S and S_W values.

1.7. Weather and climate conditions requirements

1.7.1. Tyres tested against SRTT17S according to table in paragraph 1.2.25. of this Annex shall respect the following weather and climate conditions:

(a) The average temperature during the test shall be within the following range: from 7 °C to 35 °C;

(b) The minimum and maximum temperature during the test shall be within the following range: from 2 °C to 40 °C for at least 90 per cent of test distance;

(c) No driving under snow or ice conditions is allowed;

(d) The maximum allowed percentage of the total distance driven under wet conditions is 20 per cent.

1.7.2. Tyres tested against SRTT17W according to table in paragraph 1.2.25. of this Annex shall respect the following weather and climate conditions:

1.7.2.1. Tyres for use in severe snow conditions

(a) The average temperature during the test shall be within the following range: from -3 °C to 20 °C;

(b) The minimum and maximum temperature during the test shall be within the following range: from -7 °C to 25 °C for at least 90 per cent of test distance;

(c) No driving under snow or ice conditions is allowed for more than 5 per cent of the total distance driven;

(d) The maximum allowed percentage of the total distance driven under wet conditions is 20 per cent.

1.7.2.2. Tyres not for use in severe snow conditions

(a) The average temperature during the test shall be within the following range: from -3 °C to 35 °C;

(b) The minimum and maximum temperature during the test shall be within the following range: from -7 °C to 40 °C for at least 90 per cent of test distance;

(c) No driving under snow or ice conditions is allowed for more than 5 per cent of the total distance driven;

(d) The maximum allowed percentage of the total distance driven under wet conditions is 20 per cent.

1.7.3. Weather data recording

1.7.3.1 Wet distance measurement

The wet distance, expressed as a per cent of the distance travelled, corresponds to the distance travelled with wipers on. These can be manually collected on one vehicle of the convoy. Alternatively, data can be collected from vehicle information (e.g. CAN bus -Controller Area Network- or OBD - On-Board Diagnostics-) when available.

1.7.3.2. Average temperature

For the calculation of the average temperature, a minimum 5 of measurements per shift on the circuit shall be carried out. The measurements shall include starting and arrival point. Furthermore, the temperature at the highest altitude reached on the circuit shall be measured. Measurements shall be made on at least one vehicle of the convoy.

The average temperature of the circuit shall be calculated as the average of all the measured temperatures of all 5 points.

At least at starting and arrival point, the measurement shall be done with a fixed device respecting requested accuracy. The temperature sensor shall be positioned outside in an unobstructed location, exposed to the airflow, and protected from direct solar radiation. The latter may be achieved by any shading screen or similar device.

For measurements on the road, a weather station installed in the vehicle with external temperature sensor may be used. Continuous temperature measurement throughout the test is acceptable. In this case, average, minimum, and maximum measurement should be reported for the full test. The 10 first minutes after departure and after each driver's break shall be discarded from the minimum, maximum, and average calculation. Both time-based and distance-base average for temperature are acceptable.

1.8. Standard Reference Test Tyre requirements

Reference tyres SRTT17S and SRTT17W shall be stored in condition recommended in F3676-23 and F3675-23 respectively.

SRTT17S shall be used for evaluating candidate tyres of category of use normal and for tyres of category of use snow or special use not classified as tyres for use in severe snow condition and for tyres of category of use "special use" not declared "M+S".

SRTT17W shall be used for evaluating candidate tyres of category of use snow tyres and special use tyres declared as "M+S", either or not classified as tyres for severe snow conditions.

1.9. Preparation and adjustments with respect to tyres

1.9.1. Tyre fitment on rim and vehicle

New candidate tyres shall be mounted and balanced on a rim permitted by the tyre manufacturer.

New Reference tyres for each test shall be fitted on a 7.5" rim width.

The rim width of a candidate tyre shall be reported in the test report. Tyres with special fitment requirements, such as asymmetric or directional design, shall also be mounted in accordance with these requirements: the direction of rotation shall be respected and the side of the tyre intended to face vehicle outside shall be positioned appropriately.

1.9.2. Tyre weight measurement (without rim)

The tyre weight measurement shall be done following the procedure described in paragraph 1.5.1. of this Annex.

No rubber (e.g. mould vents) shall be removed from any tyre (test or reference).

Each tyre weight shall be measured:

(a) Before being fitted on the wheel, to get the initial tyre mass (*MRTSi*) for reference tyres and (*MCTSi*) for candidate tyres;

(b) After completing the test and dismounting the tyre from the tyre wheel assembly, to get the final tyre masses (*MRTFi*) for reference tyres and (*MCTFi*) for candidate tyres.

1.9.3. Tyre and wheel assembly mass measurement

The tyre and wheel assembly mass measurement shall be done following the procedure described in paragraph 1.5.2. of this Annex.

Intermediate measurements of tyre and wheel mass assembly are optional.

1.9.4. Tyre inflation pressure

The inflation pressure of the reference tyres shall be 290 kPa.

Candidate tyres shall be inflated (cold) at their nominal pressure determined by the standard they belong to. More specifically:

(a) For standard load tyres the pressure shall be 250 kPa;

(b) For reinforced load tyres (XL) and high load capacity tyres (HL) the pressure shall be 290 kPa;

(c) The nominal pressure for nominal load as determined by the relevant standard if different from (a) and (b).

1.10. Preparation and adjustments with respect to vehicles

Vehicles for candidate and reference tyres shall be selected following the constraints of paragraph 1.6.

1.10.1. Vehicle mass measurement

The vehicle mass measurement shall be done following the procedure described in paragraph 1.5.3. of this Annex. The vehicle shall be ballasted following the specifications described in paragraph 1.6.12. of this Annex.

Measurements of each tyre load Q for reference and candidate vehicles are required.

1.10.2. Vehicle tuning

Vehicle alignments to be tuned following the provisions specified in paragraphs 1.6.2. to 1.6.6. of this Annex.

1.11. Test method and measurements

1.11.1. General

The tyre abrasion test shall be run on open roads. A maximum of 4 vehicles are allowed in a convoy. The vehicles shall drive approximately 8 000 km along selected circuits with a given driving severity with the aim of exposing each candidate tyre to the same conditions (e.g. severity, drivers, position in convoy, weather).

The tyres are evaluated relatively to a reference tyre. The reference tyre shall be fitted on one convoy's vehicle in order to absorb mainly temperature variation, but other varying parameters as well.

A candidate vehicle shall be fitted with the same candidate tyres.

The measured performance shall be calculated according to paragraph 1.11.13. of this Annex.

1.11.2. Test total distance

The total distance driven by each vehicle in the convoy shall be 8000 ± 300 km. Any total distance outside these boundaries shall invalidate the test.

1.11.3. Convoy composition and management

The convoy shall be homogeneous regarding the following vehicle parameters:

(a) Number and position of driven wheels (see paragraph 1.6. of this Annex)

(i) FWD only in the convoy;

(ii) RWD only in the convoy;

(iii) AWD (4 permanent driven wheels) only in the convoy.

(b) Propulsion energy converters (e.g. Pure internal combustion engine vehicle" (ICE), NOVC-HEVCs only, OVC-HEVs only, or PEVs only) in the same convoy. For hybrid vehicles, the provisions described in paragraph 1.6.7. of this Annex shall apply.

The same model and same settings of vehicles shall be used for both reference tyre and candidate tyre provided that:

(c) The candidate tyre size can be fitted on the same vehicle model as for the reference tyre;

(d) Loading and alignment parameters are allowed for candidate tyre.

Regarding the maximal distance between vehicles in the convoy, each driver shall be able to have visual contact with the preceding and following vehicles.

Each vehicle shall drive on the right lane (or left lane for left driving countries) when free.

1.11.4. Vehicle rotation in the convoy and driver rotation on vehicles

Each candidate tyre, including tested and reference tyres, shall run equal parts of the test:

(a) with all drivers;

(b) in all positions in the convoy.

Changes in drivers and vehicle positions may occur within a tolerance of 10 per cent of the predefined distance in the circuit.

1.11.5. Data measured before, during, and after the test

1.11.5.1. Before and after the test:

Before and after the test, the following measurements shall be done:

(a) Mass of each tyre;

(b) Load on each tyre;

(c) Wheel alignments (loaded vehicle);

(d) Tyre pressure after tyre fitment and before dismounting tyres.

1.11.5.2. During the test

During the test, the following recordings shall be performed:

(a) Continuous recordings of parameters needed for the calculation of longitudinal and lateral accelerations on each vehicle;

(b) Continuous speed measurement on each vehicle;

(c) Temperature measurement (as specified in paragraph 1.7.3. of this Annex.);

(d) Tyre pressure each day under cold conditions. By cold conditions it is meant at least 30 minutes after the last stop. Tyre shall never be deflated;

(e) Wheel alignment, in loaded condition, accompanied by correction to initial value if relevant for vehicle used for reference tyres. The wheel alignment measurement shall be carried out 4 times during the test, each at roughly a quarter of the test distance.

At intermediate stops, it is recommended but not compulsory to measure:

(f) Tyre and Wheel assembly mass;

(g) Wheel alignment, in loaded condition, accompanied by correction to initial value if relevant for vehicle used for candidate tyres.

1.11.6. Data processing for average temperature

Temperature measurement during the test:

Temperature shall be measured according to paragraph 1.7.3.

1.11.7. Data processing for test longitudinal and lateral accelerations standard deviation

During each shift, a continuous evaluation of speed, lateral, and longitudinal acceleration shall be carried out. A minimum sampling rate of 10 Hz is recommended. Most common technology is GNSS (global Navigation Satellite System) measurement associated with numerical treatment of the positions.

Acceleration data processing is defined in Appendix 1 of this Annex.

1.11.8. Test validation

The test is considered valid when the following conditions are met:

(a) Temperatures: minimum, maximum, and average temperatures as calculated in paragraph 1.11.6. of this Annex shall respect specifications defined in paragraph 1.7. of this Annex;

(b) Accelerations: the maximum and standard deviation values of the lateral and longitudinal accelerations calculated as specified paragraph 1.11.7. of this Annex shall respect the specifications defined in paragraph 1.6.13.3. of this Annex;

(c) If more than 1 500 km GNSS acceleration data are missing for the candidate tyre, the test for this candidate tyre is invalid;

(d) If more than 1 500 km GNSS acceleration data are missing for the reference tyre, the whole test is invalid;

(e) Wheel alignments at the beginning and end of test shall respect the specifications defined in paragraph 1.6. of this Annex;

(f) For candidate tyres for use in severe snow conditions, the abrasion level of the SRTT17W normalized at 10 °C ($ALRT_{10}$) shall be in the range defined in paragraph 1.6.16. of this Annex;

(g) For other candidate tyres, the abrasion level of the SRTT17S normalized at 20 °C ($ALRT_{20}$) shall be in the range defined in paragraph 1.6.16. of this Annex;

(h) A visual inspection of the reference tyres shall show no damage. The tyre sidewall marking shall still be readable. If a reference tyre was losing more than 1 cm^2 of tread chunking area, the tyre shall be considered as destroyed, and tyre destroyed process as described in paragraph 1.11.11. of this Annex shall apply.

1.11.9. Deviation from nominal circuit

The circuit is considered valid when the following provisions are met altogether:

(a) The circuit is modified by less than 10 km for the full test or if it is modified by more than 10 km and less than 30 km, for less than 8 shifts;

(b) The total driven distance remains in the 8000 ± 300 km;

(c) The abrasion level of reference tyre at 20°C is within the ranges specified in paragraph 1.6.16. of this Annex;

(d) The acceleration limits are within the ranges specified in paragraphs 1.6.13.2. and 1.6.13.3. of this Annex.

When all provisions are met the circuit is considered valid and the distance considered for calculation has to be corrected accordingly.

Accidental deviation(s) are acceptable if representing less than 20 per cent of circuit distance or less than 100 km (whichever is lower) under the condition that the reference tyre abrasion level at 20°C stays in authorized limits and acceleration standard deviations are respected.

In all other cases, the test is considered not valid and the circuit has to be revalidated.

1.11.10. Vehicle trouble handling

The following provisions apply in case of vehicle damages in the convoy:

(a) If a vehicle used in the convoy is damaged and cannot be used anymore (e.g. major mechanical failure or accident), it shall be replaced by an identical vehicle that shall be identically loaded and tuned. The replacement vehicle, equipped with the same tyres having started the test, shall run the distance lost due to vehicle failure on the lost segment of the circuit alone without the other vehicles of the convoy;

(b) If a vehicle used in the convoy is broken down and can be repaired, the lost distance shall be ran without other convoy vehicles on the lost segment of the test circuit;

(c) If the failure occurs on a candidate vehicle and not on the reference vehicle, the convoy may continue the test and the failing vehicle/tyre shall be withdrawn from the convoy. A new set of candidate tyres shall then be used for a new test, starting from scratch.

1.11.11. Tyre trouble handling

The following provisions apply in case of tyre damages in the convoy:

(a) If a tyre used during the test on the reference vehicle or one of the candidate vehicles is damaged by a reparable puncture and if the tyre can be repaired without running without pressure, the added repair mass shall be recorded and taken into account in the final calculation. The use of a spare tyre is permitted for a maximum distance of one loop 7.5 per cent of the test. The mileage ran with the spare tyre shall be recorded and taken into account for the tyre abrasion level;

(b) If a tyre used during the test is destroyed (or non-repairable puncture or ran without pressure), the mass loss of the other tyre tested on the same axle is used twice to perform the final calculation. The spare tyre used to replace the destroyed tyre should have the same size and same pattern as the replaced tyre.

1.11.12. GNSS trouble handling

If the speed and acceleration recording for one vehicle for one shift failed for more than 5 per cent of the circuit distance (because of missing satellites signal or device failure), the missing data shall be replaced with one of the other vehicles (preferably the reference vehicle) of the same convoy of the same shift, if valid.

1.11.13. Data processing for abrasion level calculation.

1.11.13.1. Reference tyre abrasion level at average test temperature (mg/km/t)

The average abrasion level at test average temperature of the reference tyre during the test is calculated as following:

$$ALRT = \frac{1000 * \sum_{i=1}^{n} (MRTS_i - MRTF_i)/D_{Ri}}{\sum_{i=1}^{n} Q_{Ri}/1000}$$

Where:

$ALRT$ is the abrasion level of the reference tyre at test average temperature in mg/km/t;

$MRTS_i$ is the mass of the reference tyre at the beginning of the test in g;

$MRTF_i$ is the mass of the reference tyre at the end of the test in g;

D_{Ri} is the total distance of the reference vehicle in km;

Q_{Ri} is the test load of the reference tyre in kg;

N is the number of tyres.

1.11.13.2. SRTT17S abrasion level calculation at 20 °C

Apply the temperature correction determined in paragraph 1.6.16.1. of this Annex to the SRTT17S abrasion level as follows:

$$ALTT_{20} = ALRT + S_S \bullet (20 - \overline{T})$$

where $\overline{T}$ is the average temperature of the test

1.11.13.3. SRTT17W abrasion level calculation at 10 °C

Apply the temperature correction determined in paragraph 1.6.16.1. of this Annex to the SRTT17W abrasion level as follows:

$$ALTT_{10} = ALRT + S_W \bullet (10 - \overline{T})$$

where $\overline{T}$ the average temperature of the test

1.11.13.4. Candidate tyre abrasion level at average test temperature (mg/km/t)

The average abrasion level at test average temperature of the candidate tyre during the test is calculated as following:

$$ALCT = \frac{1000 * \sum_{i=1}^{n} (MCTS_i - MCTF_i)/D_{Ci}}{\sum_{i=1}^{n} Q_{Ci}/1000}$$

Where:

$ALCT$ is the abrasion level of the candidate tyre at test average temperature in mg/km/t;

$MCTS_i$ is the mass of the candidate tyre at the beginning of the test in g;

$MCTF_i$ is the mass of the candidate tyre at the end of the test in g;

D_{Ci} is the total distance of the candidate vehicle in km;

Q_{Ci} is the test load of the candidate tyre in kg;

n is the number of tyres.

1.11.13.5. The abrasion index of the candidate tyre shall be independent from the average test temperature and is calculated from the following equation:

$$AICT = \frac{ALCT}{ALRT}$$

Where:

AICT is the abrasion index of the candidate tyre;

ALCT is the abrasion level of the candidate tyre at test average temperature in mg/km/t;

ALRT is the abrasion level of the reference tyre at test average temperature in mg/km/t.

1.12. Test report

1.12.1. The test report shall include the following information:

(a) Average, minimum, and maximum temperature during the test;

(b) Percentage of distance covered on wet roads;

(c) Reference of the circuit used for the test, including the circuit length, driving style distribution, and location;

(d) Total deviation distance to the nominal distance in km;

(e) Start and end date of the test.

1.12.2. For each reference tyre, the following information shall be reported:

(a) Model of vehicle used for reference tyre;

(b) Tyre data, including manufacturer, brand name, trade name, size, LI and load capacity, speed symbol, reference pressure, and serial number of the tyres;

(c) Vehicle tuning at the beginning of the test (Front axle TOE and camber, rear axle TOE and camber), in loaded condition;

(d) Vehicle tuning at each intermediate measurement of the test (Front axle TOE and camber, rear axle TOE and camber), in loaded condition;

(e) Vehicle tuning at the end of the test (Front axle TOE and camber, rear axle TOE and camber), in loaded condition;

(f) Rim width (7.5");

(g) Cold inflation pressure at the fitment;

(h) Cold inflation pressure at 50 per cent of the test;

(i) Cold inflation pressure at the end to the test;

(j) Balancing mass at the beginning of the test;

(k) Balancing mass at the end of the test;

(l) Initial tyre mass (*MRTSi*) for each reference tyre;

(m) Final tyre mass (*MRTFi*) for each reference tyre;

(n) Abrasion level in mg/km/t normalized at 20 °C

(o) Distance ran for each reference tyre;

(p) Standard deviation of longitudinal acceleration for the vehicle fitted with reference tyre;

(q) Standard deviation of lateral acceleration for the vehicle fitted with reference tyre;

(r) Percentage of distance covered over the maximum longitudinal acceleration for the vehicle fitted with reference tyre;

(s) Percentage of distance covered over the maximum lateral acceleration for the vehicle fitted with reference tyre;

(t) Percentage of time travelled over each speed range (i.e. urban-like, regional-like, and highway-like);

(u) Measured tyre load for each reference tyre;

(v) Reference tyres visual inspection report.

1.12.3. For each candidate tyre, the following information shall be reported:

(a) Model of vehicle used for candidate tyre;

(b) Tyre data, including manufacturer, brand name, trade name, size, LI and load capacity, speed symbol, reference pressure, and serial number of the tyre;

(c) Vehicle tuning at the beginning of the test (Front axle TOE and camber, rear axle TOE and camber) in loaded condition;

(d) Vehicle tuning at the end of the test (Front axle TOE and camber, rear axle TOE and camber) in loaded condition;

(e) Rim width;

(f) Cold inflation pressure at the fitment;

(g) Cold inflation pressure at 50 per cent of the test;

(h) Cold inflation pressure at the end to the test;

(i) Balancing mass at the beginning of the test;

(j) Balancing mass at the end of the test;

(k) Initial tyre mass (*MCTSi*) for each candidate tyre;

(l) Final tyre mass (*MCTFi*) for each candidate tyre;

(m) Measured tyre load for each candidate tyre;

(n) Distance run for each candidate tyre;

(o) Standard deviation of longitudinal acceleration for the vehicle fitted with candidate tyre;

(p) Standard deviation of lateral acceleration for the vehicle fitted with candidate tyre;

(q) Percentage of distance covered under the maximum longitudinal acceleration for the vehicle fitted with candidate tyre;

(r) Percentage of distance covered under the maximum lateral acceleration for the vehicle fitted with candidate tyre;

(s) Percentage of time travelled over each speed range (i.e. urban-like, regional-like, and highway-like).

1.12.4. Final test results

(a) The measured result of abrasion level ALRT for the reference tyre during the test at average test temperature as described in paragraph 1.11. of this Annex;

(b) The measured result of abrasion level ALCT for the candidate tyre during the test at average test temperature as described in paragraph 1.11. of this Annex;

(c) The final result tyre abrasion index AICT as described in paragraph 1.11.13. of this Annex.

2. Test method (b) using indoor drum

2.1. Scope

2.1.1. This method applies to C1 tyres in scope of this regulation except ice grip tyres and tyres having a nominal rim diameter code ≤ 13.

2.2. Definitions and Terms

In addition to relevant definitions provided in paragraph 2 of this Regulation the following definitions apply to the indoor drum method.

2.2.1. "Tyre abrasion" means tyre wear that is observed as the loss of tyre mass during usage.

2.2.2. "Mass loss" means amount of the mass lost due to tyre abrasion

Note 1 to entry: It is expressed in grams.

2.2.3. "Test tyre" means tyre that is used for an evaluation programme, either candidate tyres or reference tyres.

2.2.3.1. Candidate tyre

T test tyre that is part of an evaluation programme and that is evaluated with the reference tyre using the same test method.

2.2.3.2. Reference tyre

R special test tyre that is used as a benchmark in an evaluation programme.

2.2.3.2.1. "Standard Reference Test Tyre" or "SRTT" means a tyre that is produced, controlled and stored in accordance with the standards of ASTM International:

(a) F3676 - 23 for the size 225/45R17 and referred to as "SRTT17S";

(b) F3675 - 23 for the size 225/45R17 and referred to as "SRTT17W".

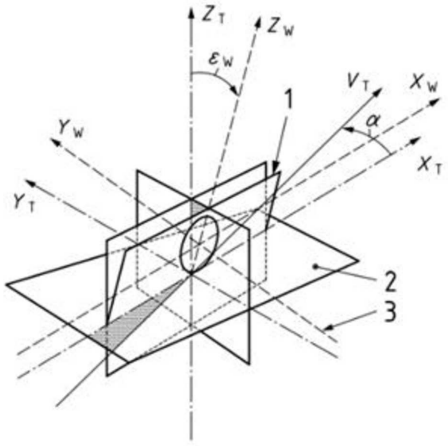
Normal reference tyre (225/45R17 94 XL ASTM F3676 - 23) shall be used for testing candidate tyres not for severe snow condition, means normal, snow and special tyres not bearing M+S nor 3PMSF marks.

Winter reference tyre (225/45R17 94 XL ASTM F3675 - 23) shall be used for testing candidate tyres for severe snow conditions (marked with 3PMSF symbol) and special use tyres bearing the marking M+S or 3PMSF.

2.2.4. "Mean profile depth" is used for the characterization of the surface roughness in macroscale and is described in ISO 13473-1.

2.2.5. "Micro-roughness" means the surface roughness characterized in microscale and is measured by altered filtering conditions as defined in ISO 13473-1.

2.2.6. "Tyre Coordination system" is tyre coordinate system specified in ISO 8855.



2.2.7. "Vertical load" means the tyre normal force of a tyre exerted on the road resulting from the mass supported by the tyre. Tyre normal force is specified in ISO 8855.

2.2.8. "Lateral force" means the force of a tyre generated in lateral direction during cornering. Tyre lateral force is specified in ISO 8855. It takes a positive sign when turning left and a negative sign when turning right.

2.2.9. "Longitudinal force" means the force of a tyre generated in the longitudinal direction during acceleration or braking. Tyre longitudinal force is specified in ISO 8855. It takes a positive sign for speed increase and a negative sign for speed decrease (e.g. braking).

2.2.10. "Loaded radius" means the distance from the tyre axis to the drum outer surface under steady-state conditions at 0 speed and 0 camber as well while the test load and inflation pressure is applied at room temperature and refer to the thermal conditioning of paragraph 2.6.2.

2.2.11. "Tyre torque" means the moment on tyre rotation axle.

2.2.12. "Load index" means numerical code associated with the maximum load a tyre can carry at the speed indicated by its speed symbol under the service conditions specified by the tyre manufacturer.

2.3. Symbols and Abbreviated terms

In addition to relevant symbols and abbreviated terms provided in paragraph 1 of Annex 10 of this Regulation the following symbols and abbreviated terms apply to the indoor drum method.

Symbol	Unit	Designation
T	No dimension	Candidate tyre
R	No dimension	Reference tyre
Fz	N	Vertical load
Fy	N	Lateral force
Fx	N	Longitudinal force
r_L	m	Loaded radius

Symbol	Unit	Designation
My	Nm	Tyre torque
LI	No dimension	Load Index
MPD	mm	Mean Profile Depth

2.4. Test Method

2.4.1. General

This test method evaluates the mass loss of the candidate tyre relative to the reference tyre.

In measuring tyre tread wear per distance travelled, it is necessary to control normal load, lateral force, and longitudinal force applied to a test tyre.

This test method uses a tread wear test equipment with a cylindrical flywheel (drum) with external surface of drum.

2.4.2. Drum Specifications

2.4.2.1. Tyre Wear Test Equipment

Tyre wear test equipment shall consist of a drum, a tyre carriage device, a loading device, and adhesion prevention system. There can be one or two carriage devices.

2.4.2.2. Drum Diameter

The test dynamometer shall have a cylindrical flywheel (drum) with a diameter of at least 3 m.

2.4.2.3. Test Surface

The test surface shall be applied to external surface of the cylindrical drum. The test surface of drum shall meet the following minimum requirements:

(a) The test surface of the drum shall have a MPD measured at the start and the end of the drum test not exceeding 2,0 mm, according to ISO 13473-1;

(b) The test surface of the drum shall have a micro-roughness measured at the start and end of the drum test within the range from 0.07 mm to 0.4 mm. The measuring method of MPD described in ISO 13473-1 shall apply to the measurement of micro-roughness, except for sampling interval, resampling, high-pass and low-pass filtering, and segment length. The sampling interval shall not be more than 0.033 mm, and samples shall be taken at a fixed interval in the horizontal direction. Re-sample the signal to either 0.017 mm (preferably) or 0.033 mm spacing. For high-pass and low-pass filtering, the filters shall be of the Butterworth type, 2nd order, and shall have a cut-off at 3.0 mm and 0.1 mm texture wavelength, respectively. The segment length shall be 3.33 mm ± 0.33 mm;

(c) The test surface of the drum shall be textured with sands, stones, or an alternative material, e.g., aluminium oxide resin;

(d) The drum surface shall be built with rigid and not deformable material;

(e) The test surface, including voids, shall be dry and clean during the entire measurement procedure and for all measurements;

(f) The device for measurement of the MPD must fulfil the specifications of ISO 13473-3. The device for measurement of micro-roughness must fulfil the specifications of ISO 13473-3, except for horizontal resolution, which shall not be more than 0.033 mm.

The abrasion level of the SRTT17S reference tyre for all types of surface shall be in the range between 50 mg/km/t and 190 mg/km/t.

The abrasion level of the SRTT17W reference tyre for all types of surface shall be in the range between 35 mg/km/t and 165 mg/km/t. The abrasion level shall be calculated according to the method in paragraph 2.8. of this Annex. In case of sand paper used for surface it shall be replaced as specified in Appendix 5.

When the drum surface no longer satisfies the conditions of the previous period, the surface shall be replaced. Intermediate inspection of the abrasion rate for the reference tyre is recommended.

2.4.2.4. Width

The width of the test surface shall always exceed the width of the test tyre contact patch throughout entire test duration.

2.4.3. Tyre Carriage and Drive System

The tyre carriage and drive system shall be able to provide dynamic control of:

(a) tyre lateral force developed by the drag force produced by tyre slip angle during running;

(b) Longitudinal tyre force or torque developed by tractive force by the tyre during braking and accelerating.

The maximum allowed deviation from the nominal value of load (Fz), lateral force (Fy), longitudinal force (Fx), and tyre torque (My) during testing is defined as follows:

(c) Fz: ±50N or 1 per cent whichever is greater;

(d) Fy: ± 100N or 5 per cent whichever is greater, for the difference between input peaks and actually generated peaks;

(e) Fx: ± 100N or 5 per cent whichever is greater, for the difference between input peaks and actually generated peaks;

(f) My: ±40Nm or 5 per cent whichever is greater, for the difference between input peaks and actually generated peaks.

2.4.4. Adhesion Prevention System

2.4.4.1. Powder Distribution

The treadwear test equipment shall have a powder distribution system to spray a controlled volume of either talc or silica. Mixture of talc and silica is not allowed. The powder particle typical size can range from 0,1 μm to 100 μm.

The powder distribution system shall spray on the test surface near the test tyre contact patch so that abrasion fragments do not adhere to the tyre or test drum surface. Powder distribution system and materials shall be identical for both reference tyre and candidate tyre during a test and shall remain constant during the entire test. The powder delivery rate (measured by mass or volume) applied to the reference and candidate tyres shall be the same, with a maximum ±10 per cent difference for each test.

2.4.4.2. Nozzle Position

The nozzle position for powder distribution system shall follow at least one of the following specifications:

(a) Blow-in type: In case of only one nozzle, centre of the nozzle shall be positioned in symmetrical plane. The distance between nozzles and centre of contact patch shall be at lower than 35 cm from centre of contact patch.

In case of multiple nozzles, they shall be placed parallel to the Y axis and symmetrically distributed respective to the X axis. The distance between nozzles and centre of contact patch shall be lower than 35 cm. Nozzles shall be oriented towards contact patch entrance.

(b) Dispersion type: The tester shall be covered with the enclosure coverings. Powder shall be evenly dispersed within the enclosure. The nozzle/nozzles shall be placed parallel to the Y axis and symmetrically distributed respective to the X axis.

2.4.5 Load, Alignment, Control and Instrumental Accuracies

Measurement of these parameters shall be sufficiently accurate and precise to provide the required test data. The specific and respective values are provided in Appendix 4 of this Annex.

2.4.6 Mass Scale

The mass scale for test tyres shall have:

(a) A mass capacity being able to weigh test tyre;

(b) An accuracy within ±2 g.

The mass scale shall be duly calibrated following the requirements defined by the manufacturer.

2.5. Test Conditions

2.5.1 General

The test consists of a measurement of tyre mass loss in which the tyre is inflated to the cold pressure as specified in paragraph 2.5.3. of this Annex and the inflation pressure shall be allowed to build up (i.e. "capped inflation") and not be regulated by machine.

2.5.2 Test Load

The standard test load Fz on the tyre to be measured shall be calculated from its LI load, corresponding to the maximum mass associated with the LI of the tyre.

The standard test load shall be computed from the values shown in Table 1 and shall be kept within the tolerance specified in Appendix 4 of this Annex.

2.5.3 Tyre Inflation Pressure

The inflation pressure shall be set in accordance with that shown in Table 1 with the accuracy specified in Appendix 4 of this Annex and shall be capped.

Table 1

Test loads and inflation pressures

Tyre type	C1 [a]	
	Standard load or light load	Reinforced or extra load
Load -% of maximum load capacity	80	80
Inflation pressure [b] (kPa)	210	250

[a] For those C1 tyres belonging to categories which are not shown in ISO 4000-1:2015, Annex B, the inflation pressure shall be the inflation pressure recommended by the tyre manufacturer, corresponding to the maximum tyre load capacity, reduced by 30 kPa.

[b] The inflation pressure shall be capped with the accuracy specified in Appendix 4.

2.5.4 Testing Conditions (Longitudinal force, lateral force, test speed, running distance)

The following testing conditions shall be met for a test to be considered valid:

(a) Longitudinal force and lateral force shall be computed from the values shown in Appendix 3 of this Annex. Speed shall be in accordance with that shown in Appendix 4 of this Annex;

(b) The total running distance of the test shall be 5 000 km. The total distance of an actual test shall not differ more than ± 5 per cent from the total input distance;

(c) The reference tyre shall be mounted on a rim with a width of 7.5 inches. New candidate tyres shall be mounted on any rim requested and approved by the tyre manufacturer;

(d) The rim width of candidate tyre shall be recorded. Tyres with special fitment requirements, such as asymmetric or directional design, shall also be mounted in accordance with these requirements: direction of rotation shall be respected;

(e) The test shall be performed at null camber (0°).

2.6. Test Procedure

2.6.1. General

The test procedure steps described below shall be followed in the given sequence:

(a) Both reference and candidate tyres shall be new when starting the test;

(b) Test tyres with specified direction of rotation shall be rolling in the forward direction;

(c) The direction of rolling shall be kept the same throughout the test;

(d) The abrasion level calculation shall use the actual test run distance.

2.6.2. Thermal Conditioning

The inflated tyre shall be placed in the thermal environment of the test location for a minimum of 3 h.

2.6.3. Pressure Adjustment

After thermal conditioning, the inflation pressure shall be adjusted to the test pressure.

2.6.4. Thermal Environment

During the test, the ambient temperature shall be kept at 25 °C ± 5 °C. The ambient temperature shall be measured at a distance of not less than 0.15 m and not more than 1 m from the tyre.

The average ambient temperature for reference and candidate tyres during testing shall not differ by more than 2 °C.

2.6.5. Mass Measurement

The mass of tyre shall be measured before and after 5 000 km of run as defined in paragraph 2.6.6. of this Annex for both reference and candidate tyres.

2.6.6. Test Cycle

2.6.6.1. Input Condition

Both reference tyre and candidate tyre shall be tested according to input condition of Appendix 3 of this Annex. The Appendix 3 test condition of 250 km is defined as one test cycle, and the test cycle shall be repeated 20 times until 5 000 km is reached.

2.6.6.2. Default Test Program (2 positions drum)

Both reference tyre and candidate tyre shall be mounted at different positions of one drum. Testing of both reference tyre and candidate tyre shall be conducted at the same time.

Tyres mounted at the two positions shall be exchanged once after the completion of 2 500 km. The direction of rotation shall remain constant throughout the test.

A visual inspection of the tyres is recommended after the completion of 2 500 km to ensure no tread chunking.

2.6.6.3. Alternative Test Program (1 position drum)

In case testing of reference tyre and candidate tyre is not possible at the same time, the alternative test program may be followed. The following test order for the Reference tyre (R) and Candidate tyre (T) shall be followed:

R (1 000 km) – T (2 000 km) – R (2 000 km) – T (2 000 km) – R (2 000 km) – T (1 000 km)

Repeat a set of Appendix 3 input conditions 4 times for 1 000 km and 8 times for 2 000 km.

A visual inspection of tyre is recommended around the completion of 2 500 km to ensure no tread chunking.

2.6.6.4. Test Starting Phase

The tyres shall touch the drum with speed that equals 0 km/h. Then the test load Fz shall be applied at speed equal to 0 km/h or at very low speed. After load application, speed can be increased to the initial test value 60 km/h with a maximum longitudinal acceleration of 0.125 m/s^2 or maximum travelled distance of 3.5 km. This starting phase shall be free rolling conditions. The distance run during the starting phase shall not be counted.

2.6.7. Measurement and Recording

Table 2 summarizes the items that shall be measured and recorded:

Table 2

Parameters to be measured and recorded over the drum test

Item	Requirements
(a) Test speed	Sampling frequency ≥ 1Hz
(b) Tyre normal force to the drum surface	Sampling frequency ≥ 1Hz
(c) Test inflation pressure: initial and end of the test, as defined in 2.6.3	Shall measure: — Before starting the test; — 3 or more hours after end of the test. Interim measurement during test is optional
(d) Ambient temperature measured in °C, t_{amb}	Sampling frequency ≥ 1Hz
(e) Lateral force applied to the test tyre during the test	Sampling frequency ≥ 10 Hz
(f) Longitudinal force or torque applied to the test tyre during the test	Sampling frequency ≥ 10 Hz
(g) Mass of tyre	Shall measure: — Before starting the test; — 3 or more hours after end of the test. Interim measurement during test is optional

Item	Requirements
(h) MPD and micro-roughness of the test surface;	Shall measure at the timings of: — Before starting the test; — 3 or more hours after end of the test. Interim measurement during test is optional
(i) Photograph of tyres after test program	Photograph of tyres after test to record the surface as a proof of test completion in the right way.

During the measurement of the force or torque applied to the test tyre, a moving average over one-wheel revolution may be used to eliminate first and/or second harmonic of the tyre.

During the measurement of the force or torque applied to the test tyre, a low pass filter may be used to eliminate first and/or second harmonic of the tyre.

2.7. Validation

When a tyre has been subjected to the test method specified in paragraph 2.5. of this Annex using a test rim and a valve that undergo no permanent deformation and allow no loss of air, there shall be no visual evidence of tread, sidewall, ply, cord, inner liner, belt or bead separation, chunking, open splices, cracking, broken cords, or rubber adhesion.

A visual inspection of reference tyres shall show no damage on reference tyres. If a reference tyre loses more than a total of 1 cm^2 of tread area (due to chunking or other mechanism), the tyre shall be considered as destroyed and the test as invalid.

The following values measured from each parameter shall be with their tolerances as specified in Table 3. Otherwise, the test results shall be rejected.

Table 3

Validation of Fx, Fy, Fz

Parameter	Measurement	Value to be verified	Tolerance
Fx	RMS (a) of G(x)	RMS_{Gx} = 0,059	±5 %
Fy	RMS (a) of G(y)	RMS_{Gy} = 0,074	±5 %
Fx and Fy	RMS (a) of G(x, y)	RMS_{Gxy} = 0,095	±5 %
Fz	RMS of Fz applied filter divided by Fz nominal	Average of Fz	±50 N or ±1 %, whichever is greater

Note 1 to entry:
(a) For the whole test of total 5 000 km, calculate the Root Mean Square (RMS) of *G*(x) and *G*(y) using the equations below:

$$RMS_{Gx} = \sqrt{\frac{1}{N} \times \sum_{i=1}^{N} \left(\frac{Fx_i}{Fz_i}\right)^2}$$

$$RMS_{Gy} = \sqrt{\frac{1}{N} \times \sum_{i=1}^{N} \left(\frac{Fy_i}{Fz_i}\right)^2}$$

$$RMS_{Gxy} = \sqrt{\frac{1}{N} \times \sum_{i=1}^{N} \frac{(Fx_i)^2 + (Fy_i)^2}{(Average\ of\ Fz)^2}}$$

Where;
i is the number of data acquired at a sampling frequency of 10 Hz;
N is the total number of data acquired;
Fx, *Fy* and *My* may be filtered by a low pass filter to remove noise of the output;
Fz shall be filtered as the moving average per one second.

2.8. Processing of Measurement Results

The calculation method for the abrasion index and the abrasion level shall follow the equations:

$$MlT = MT_b - MT_a$$

$$MlR = MR_b - MR_a$$

Where:

MlT is Mass loss of candidate tyre, in grams

MlR is Mass loss of reference tyre, in grams

MT_b is Mass of candidate tyre before test cycle, in grams

MT_a is Mass of candidate tyre after test cycle, in grams

MR_b is Mass of reference tyre before test cycle, in grams

MR_a is Mass of reference tyre after test cycle, in grams

The abrasion index (AICT) shall be calculated according to the following equation:

$$AICT = ArT/ArR$$

Where

ArT Normalized abrasion rate (mg/km/t) of candidate tyre,
ArT = MlT (g)/DT(km)/Fz,T(t) x 1000 (mg/kg)

ArR Normalized abrasion rate (mg/km/t) of reference tyre,
ArR = MlR (g)/DR(km)/Fz,R(t) x 1000 (mg/kg)

DT Testing mileage of candidate tyre (km)

DR Testing mileage of reference tyre (km)

Fz,T Test load (t) of candidate tyre

Fz,R Test load (t) of reference tyre

The reference tyre used to calculate the abrasion index shall be one of the tyres described in 2.2.3.2.1. of this Annex.

2.9. Test report

2.9.1. The test report shall include the following information:

(a) Test machine identification;

(b) Drum circumference (m);

(c) Test cycle (2 positions /1 position);

(d) 3rd body (Mineral / Clay);

(e) MPD of test surface (mm): Beginning of test / End of test;

(f) Tyre class;

(g) Brand;

(h) Pattern/trade description;

(i) Tyre size designation;

(j) Service description;

(k) Test load (N);

(l) Test inflation pressure (kPa);

(m) Tyre identification;

(n) 3PMSF marking (Y/N);

(o) Rim width (inch);

(p) Inflation pressure (kPa): Beginning of test / End of test;

(q) Mass of tyre (g): Before test / After test;

(r) Test distance (km);

(s) Abrasion rate (mg/km);

(t) Abrasion level (mg/km/t);

(u) Abrasion index (only applicable for candidate tyre);

(v) Average ambient temperature (°C);

(w) RMS of G(x);

(x) RMS of G(y);

(y) Average of Fz.

Annex 10 – Appendix 1

Test method (a) - Accelerations calculation

1. Input for calculation

1.1. Required parameters

The following parameters are required for the calculation of longitudinal and lateral acceleration:

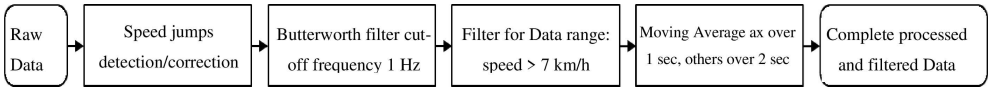
(a) The vehicle velocity (v), [m/s]

(b) The longitudinal acceleration ($a_{longitudinal}$), [m/s^2]

(c) The lateral acceleration ($a_{lateral}$), [m/s^2]

The accelerations are derived by evaluation of GNSS (GLOBAL NAVIGATION SATELLITE SYSTEM as defined by ISO 24245:2023) signals. The recommended sampling rate is 10 Hz or more. Otherwise, the below described filtering process is not working.

Filter for measured Values



1.2. Speed jumps detection and correction

Before starting the filtering process, all measured values are checked concerning speed jumps. Speed jumps refer to measurements which are not plausible. For identifying speed jumps, the velocity is filtered by using a Butterworth filter with a cut-off frequency of 1 Hz. A threshold of 9 m/s^2 for the maximum longitudinal acceleration is defined. That means, that a speed change of maximum 9 $m/s^2 \bullet t_{sampling}$ is still plausible.

A speed jump will be detected if there is a speed difference of $2 \bullet \Delta speed_{possible}$. In case of a detected speed jump, the relevant raw speed values will be replaced by a linear interpolated value.

1.3. Butterworth Filter:

For filtering the measurement, a Butterworth filter second order with a cut-off frequency of 1 Hz is used. After this filter the values are smoothed with a "moving average" over 1 second for longitudinal acceleration, all other values over 2 seconds.

All accelerations measured for a velocity less than 7 km/h are excluded.

Python code:

```
from scipy.signal import butter, filtfilt
# Filter settings: n_order is the order of the filter,
# A scalar or length-2 sequence giving the critical frequencies
N = 2
Wn = 1 / (0.5 * round(data_inp['freq_sample'].mean()))
[b,a] = butter(N, Wn, 'lowpass')
data_filt = filtfilt(b, a, data_inp, padtype = 'odd')
data_inp = data_inp[(data_inp.speed_filt > speed_min)]
```

1.4. Moving Average:

Python code:

```
# averaging over 1 second window
# make sure window is odd
if round(data_inp['freq_sample'].mean()) % 2 != 0:
                win = int(round(data_inp['freq_sample'].mean()))
else:
                win = int(round(data_inp['freq_sample'].mean()) - 1)
data_inp['accx_filt_movg'] = data_inp['accx_filt'].rolling(window=win,,
center=True, min_periods=1).mean()
# averaging over 2 second window
win = int(round(data_inp['freq_sample'].mean()) * 2 - 1)
data_inp['accy_filt_movg'] = data_inp['accy_filt'].rolling(window=win,
center=True, min_periods=1).mean()
data_inp['speed_filt_movg'] = data_inp['speed_filt'].rolling(window=win,
center=True, min_periods=1).mean()
```

1.5. Distance-based Standard Deviation

Calculated accelerations (sampled with a constant frequency) are transferred in distance-based values: one value per meter. For this, a simple interpolation is used. With these accelerations, the standard deviation can be calculated with following well-known formulas:

$$s_{longitudinal} = \sqrt{\frac{1}{N-1} \bullet \sum_{i=1}^{N} (a_{longitudinal,i} - \mu_{longitudinal})^2}$$

with $\mu_{longitudinal} = \frac{1}{N} \sum_{i=1}^{N} a_{longitudinal,i}$

$$s_{lateral} = \sqrt{\frac{1}{N-1} \bullet \sum_{i=1}^{N} (a_{lateral,i} - \mu_{lateral})^2}$$

with $\mu_{lateral} = \frac{1}{N} \sum_{i=1}^{N} a_{lateral,i}$

Python code:

```
from scipy import interpolate
import numpy as np
data_inp['distance'] = data_inp['speed']/data_inp['fsample']
data_inp['distance'] = data_inp['distance'].cumsum()

# interpolate function for acc
f_accx = interpolate.interp1d(data_inp['distance'], data_inp['accx'])
f_accy = interpolate.interp1d(data_inp['distance'], data_inp['accy'])

# generate array of distance every 1m
distance_1m = np.array(data_inp['distance'].iloc[0], data_inp['distance'].iloc[-1], 1)

# create an interpolation every 1m for the accelarations - numpy array result
# len of the array same as len of distance_1m
accx_DB = f_accx(distance_1m)
accy_DB = f_accy(distance_1m)

# compute the stadx with ceiling accx_DB and accy_DB
stdax = np.std(accx_DB)
stday = np.std(accy_DB)
```

2. Calculation of distribution of driving styles

The following steps shall be followed for the calculation of the distribution of driving styles:

(a) Cumulate 8 000 km of acceleration data on a vehicle at the circuit. The accelerations data obtained while qualifying the circuit for abrasiveness may be used. The provisions defined for vehicle speed in paragraph 1.6.13.2. (d) of this Annex shall be respected in every single convoy test;

(b) Split the data in segments of 20 km;

(c) Compute the longitudinal and lateral acceleration standard deviations ($S_{longitudinal}$; $S_{lateral}$) for each segment, following the method described in paragraph 1. of this appendix;

(d) For each segment with ($S_{longitudinal}$; $S_{lateral}$) data, count which road driving style (as defined in paragraph 1.6.13.2.) it belongs to. This shall be done by attributing it to urban-like driving style if matching the corresponding criteria, to highway-like driving style if matching the corresponding criteria, or to regional-like driving style if not matching the urban-like or highway-like driving style;

(e) The share of points in one road driving style equals to the number of points in the road driving style divided by the total number of segments. This share shall respect the shares defined in paragraph 1.6.13.2.

Annex 10 – Appendix 2

Test method (a) - Test report example for the vehicle method

Tyre abrasion rate test report					
Test conditions					
Test Starting date		Test end date			
Test temperatures: (degree C)					
Average		Minimum		Maximum	
Percentage of distance covered on wet road:		(add snow)			

Circuit used for test:			
Reference:		Location	
Nominal circuit length		Total distance covered	
Highway-like driving distance:		Regional-like style distance:	
Urban-like driving style distance:		Total deviation distance	
Slope of reference tyre sensitivity to temperature:			

	Candidate tyre/vehicle				Reference tyre/vehicle			
	Front Left	Front right	Rear left	Rear right	Front Left	Front right	Rear left	Rear right
Vehicle information								
Vehicle model								
Standard deviation X acceleration								
% of distance covered under the maximum longitudinal acceleration								
Standard deviation Y acceleration								
% of distance covered under the maximum lateral acceleration								
Toe at test start								
Camber at test start								
Toe at test end								
Camber at test end								
Load per position								
Tyre information								

	Candidate tyre/vehicle				Reference tyre/vehicle			
	Front Left	Front right	Rear left	Rear right	Front Left	Front right	Rear left	Rear right
Tyre brand								
Tyre pattern								
Tyre size designation								
Tyre load capacity index								
Speed category								
Serial number (if available)								
Cold inflation pressure (fitment)								
Cold inflation pressure 50% test								
Cold inflation pressure (test end)								
Balancing mass (test beginning)								
Balancing mass (test end)								
Rim width					7,5"	7,5"	7,5"	7,5"
Initial tyre mass								
Final tyre mass								
Distance run by each tyre								
Reference tyre abrasion level in mg/km/t normalized at 20°C (or 10°C)								
Tyres visual inspection report								
Test results								
Tyre Abrasion level in mg/km/t								
Tyre Abrasion index					N/A			

Annex 10 – Appendix 3

Test method (b) - Input of test cycle

In order to calculate the input forces Fx and Fy, longitudinal and lateral acceleration indices, as G(x) and G(y) respectively, are introduced as below.

For torque control testing machine, tyre torque (My) is calculated with longitudinal force (Fx) and loaded radius (RL) following the equations provided below:

$$Fx = Fz \times G(x) \text{ or } My = \text{Test load}(Fz) \times G(x) \times RL$$

$$Fy = Fz \times G(y)$$

Fz is the test load defined in 2.2.8 and 2.5.2.

G(x) and G(y) represent the index compared to the standard acceleration due to earth gravity (g= 9.80665 m/s^2). Alternatively, the local earth gravity may be defined.

Table A1 defines the time, G(x), G(y), and speed of test cycle. In Table A1, T represents the total test duration from the beginning of the test. At a point of test duration T, the values of G(x) and G(y) shall be equal to those listed in Table A1.

G(x) and G(y) shall change linearly between two adjacent points. Therefore, the values of Fx and Fy will also change linearly from one point to another. The following graphs show samples of linear change for Fx or Fy with respect to T.

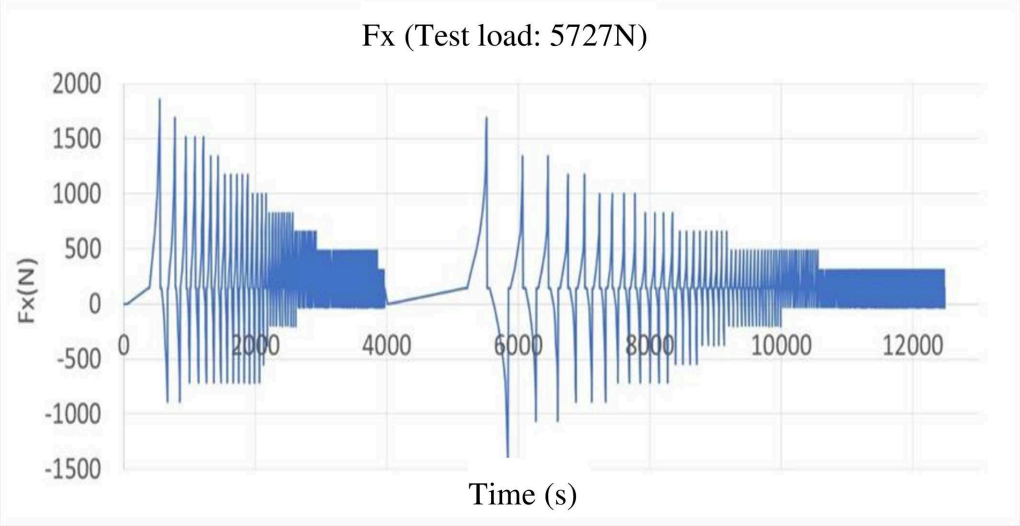
T means the driving time from starting test.

The value of G(x) and G(y) at driving time T is mentioned in Table A1.

G(x) and G(y) between each point changes linearly through those two points.

Graph A.1

Example of Fx , with a test load of 5 727N



Graph A.2

Example of Fy , with a test load of 5 727N

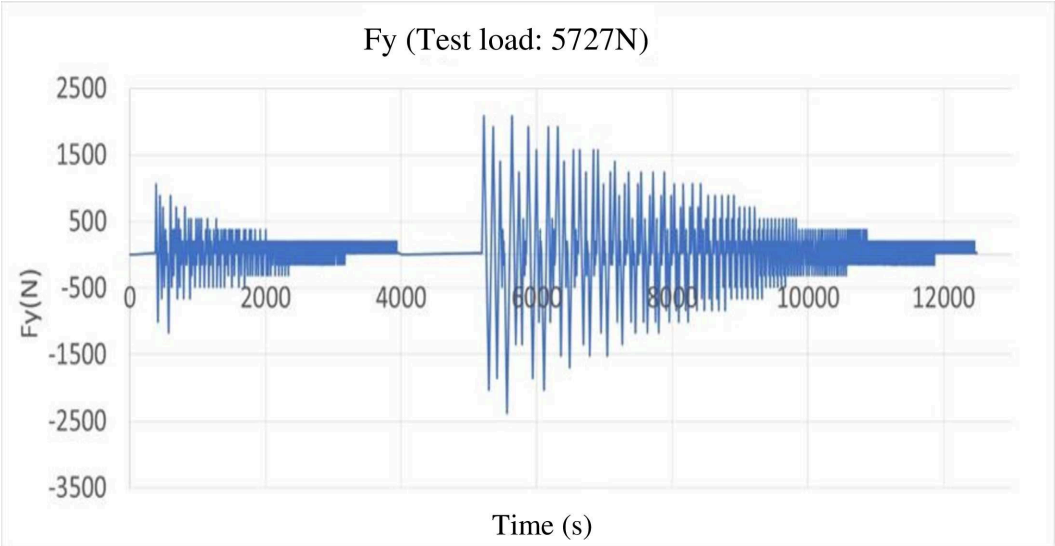


Table A1.

Input of test cycle

T (*s*)	*v* (*kph*)	*G(x)*	*G(y)*
0	60	0,000	0
50	100	0,000	0,000
373,2	100	0,025	0,005
388,4	100	0,025	0,185
418,7	100	0,055	- 0,175
446,5	100	0,085	0,155
471,7	100	0,115	- 0,115
491,9	100	0,145	0,125
509,6	100	0,175	- 0,085
522,3	100	0,205	0,065
532,4	100	0,235	- 0,025
540,0	100	0,265	0,035
545,0	100	0,295	0,005
547,5	100	0,325	0,005
556,8	100	0,025	0,005
574,5	100	0,025	- 0,205
602,3	100	- 0,005	0,155
620,0	100	- 0,035	- 0,085
632,6	100	- 0,065	0,065
645,2	100	- 0,095	- 0,055
657,9	100	- 0,125	0,065
662,9	100	- 0,155	0,005
668,8	100	0,025	0,005
678,9	100	0,025	0,125
699,1	100	0,055	- 0,115
719,3	100	0,085	0,095
737,0	100	0,115	- 0,085
747,1	100	0,145	0,065
757,2	100	0,175	- 0,025
764,8	100	0,205	0,035
769,9	100	0,235	0,005
774,9	100	0,265	0,035
777,4	100	0,295	0,005
785,9	100	0,025	0,005
796,0	100	0,025	- 0,115
816,2	100	- 0,005	0,125
826,3	100	- 0,035	- 0,025
833,9	100	- 0,065	0,035
841,4	100	- 0,095	- 0,025
849,0	100	- 0,125	0,035
851,6	100	- 0,155	0,005
857,4	100	0,025	0,005

865,0	100	0,025	0,095
885,2	100	0,055	- 0,115
902,9	100	0,085	0,095
915,6	100	0,115	- 0,055
923,1	100	0,145	0,035
930,7	100	0,175	- 0,025
935,8	100	0,205	0,035
940,8	100	0,235	0,005
945,9	100	0,265	0,035
953,5	100	0,025	0,005
961,0	100	0,025	- 0,085
978,7	100	- 0,005	0,095
986,3	100	- 0,035	- 0,025
991,3	100	- 0,065	0,035
996,4	100	- 0,095	0,005
1 001,5	100	- 0,125	0,035
1 006,5	100	0,025	0,005
1 014,1	100	0,025	0,095
1 031,8	100	0,055	- 0,085
1 049,5	100	0,085	0,095
1 059,6	100	0,115	- 0,025
1 067,1	100	0,145	0,035
1 072,2	100	0,175	0,005
1 077,2	100	0,205	0,035
1 082,3	100	0,235	0,005
1 084,8	100	0,265	0,005
1 092,4	100	0,025	0,005
1 100,0	100	0,025	- 0,085
1 112,6	100	- 0,005	0,065
1 120,2	100	- 0,035	- 0,025
1 125,3	100	- 0,065	0,035
1 130,3	100	- 0,095	0,005
1 135,4	100	- 0,125	0,035
1 140,4	100	0,025	0,005
1 148,0	100	0,025	0,095
1 165,7	100	0,055	- 0,085
1 180,8	100	0,085	0,065
1 188,4	100	0,115	- 0,025
1 193,5	100	0,145	0,035
1 198,5	100	0,175	0,005
1 203,6	100	0,205	0,035
1 206,1	100	0,235	0,005
1 208,6	100	0,265	0,005
1 216,2	100	0,025	0,005
1 223,8	100	0,025	- 0,085
1 236,4	100	- 0,005	0,065
1 241,5	100	- 0,035	0,005
1 246,5	100	- 0,065	0,035
1 251,6	100	- 0,095	0,005
1 256,6	100	- 0,125	0,035
1 261,7	100	0,025	0,005
1 269,3	100	0,025	0,095
1 284,4	100	0,055	- 0,085
1 299,6	100	0,085	0,065
1 307,2	100	0,115	- 0,025
1 312,2	100	0,145	0,035
1 317,3	100	0,175	0,005
1 322,3	100	0,205	0,035
1 324,8	100	0,235	0,005
1 331,6	100	0,025	0,005
1 339,2	100	0,025	- 0,085
1 351,8	100	- 0,005	0,065
1 356,8	100	- 0,035	0,005
1 361,9	100	- 0,065	0,035
1 366,9	100	- 0,095	0,005
1 372,0	100	- 0,125	0,035
1 377,1	100	0,025	0,005
1 382,1	100	0,025	0,065
1 397,3	100	0,055	- 0,085
1 409,9	100	0,085	0,065
1 417,5	100	0,115	- 0,025
1 422,5	100	0,145	0,035
1 427,6	100	0,175	0,005
1 432,6	100	0,205	0,035
1 435,2	100	0,235	0,005
1 441,9	100	0,025	0,005
1 447,0	100	0,025	- 0,055
1 457,1	100	- 0,005	0,065
1 462,1	100	- 0,035	0,005
1 467,2	100	- 0,065	0,035

1 472,2	100	- 0,095	0,005
1 477,3	100	- 0,125	0,035
1 482,3	100	0,025	0,005
1 487,4	100	0,025	0,065
1 502,5	100	0,055	- 0,085
1 515,2	100	0,085	0,065
1 522,7	100	0,115	- 0,025
1 527,8	100	0,145	0,035
1 532,9	100	0,175	0,005
1 535,4	100	0,205	0,005
1 541,3	100	0,025	0,005
1 546,3	100	0,025	- 0,055
1 556,4	100	- 0,005	0,065
1 561,5	100	- 0,035	0,005
1 566,5	100	- 0,065	0,035
1 571,6	100	- 0,095	0,005
1 576,6	100	- 0,125	0,035
1 581,7	100	0,025	0,005
1 586,8	100	0,025	0,065
1 601,9	100	0,055	- 0,085
1 614,5	100	0,085	0,065
1 619,6	100	0,115	0,005
1 624,6	100	0,145	0,035
1 629,7	100	0,175	0,005
1 632,2	100	0,205	0,005
1 638,1	100	0,025	0,005
1 643,2	100	0,025	- 0,055
1 650,8	100	- 0,005	0,035
1 655,8	100	- 0,035	0,005
1 660,9	100	- 0,065	0,035
1 663,4	100	- 0,095	0,005
1 665,9	100	- 0,125	0,005
1 671,0	100	0,025	0,005
1 676,0	100	0,025	0,065
1 691,2	100	0,055	- 0,085
1 703,8	100	0,085	0,065
1 708,9	100	0,115	0,005
1 713,9	100	0,145	0,035
1 719,0	100	0,175	0,005
1 721,5	100	0,205	0,005
1 727,4	100	0,025	0,005
1 732,4	100	0,025	- 0,055
1 740,0	100	- 0,005	0,035
1 745,1	100	- 0,035	0,005
1 747,6	100	- 0,065	0,005
1 750,1	100	- 0,095	0,005
1 752,7	100	- 0,125	0,005
1 757,7	100	0,025	0,005
1 762,8	100	0,025	0,065
1 775,4	100	0,055	- 0,055
1 788,0	100	0,085	0,065
1 793,1	100	0,115	0,005
1 798,1	100	0,145	0,035
1 800,7	100	0,175	0,005
1 803,2	100	0,205	0,005
1 809,1	100	0,025	0,005
1 814,1	100	0,025	- 0,055
1 821,7	100	- 0,005	0,035
1 826,8	100	- 0,035	0,005
1 829,3	100	- 0,065	0,005
1 831,8	100	- 0,095	0,005
1 834,3	100	- 0,125	0,005
1 839,4	100	0,025	0,005
1 844,5	100	0,025	0,065
1 857,1	100	0,055	- 0,055
1 867,2	100	0,085	0,035
1 872,2	100	0,115	0,005
1 877,3	100	0,145	0,035
1 879,8	100	0,175	0,005
1 882,3	100	0,205	0,005
1 888,2	100	0,025	0,005
1 893,3	100	0,025	- 0,055
1 900,9	100	- 0,005	0,035
1 905,9	100	- 0,035	0,005
1 908,5	100	- 0,065	0,005
1 911,0	100	- 0,095	0,005
1 913,5	100	- 0,125	0,005
1 918,6	100	0,025	0,005
1 923,6	100	0,025	0,065
1 936,2	100	0,055	- 0,055

1 946,4	100	0,085	0,035
1 951,4	100	0,115	0,005
1 956,5	100	0,145	0,035
1 959,0	100	0,175	0,005
1 964,0	100	0,025	0,005
1 969,1	100	0,025	- 0,055
1 976,7	100	- 0,005	0,035
1 981,7	100	- 0,035	0,005
1 984,2	100	- 0,065	0,005
1 986,8	100	- 0,095	0,005
1 989,3	100	- 0,125	0,005
1 994,4	100	0,025	0,005
1 999,4	100	0,025	0,065
2 009,5	100	0,055	- 0,055
2 019,6	100	0,085	0,035
2 024,7	100	0,115	0,005
2 029,7	100	0,145	0,035
2 032,3	100	0,175	0,005
2 037,3	100	0,025	0,005
2 042,4	100	0,025	- 0,055
2 049,9	100	- 0,005	0,035
2 055,0	100	- 0,035	0,005
2 057,5	100	- 0,065	0,005
2 060,0	100	- 0,095	0,005
2 062,6	100	- 0,125	0,005
2 067,6	100	0,025	0,005
2 070,1	100	0,025	0,035
2 080,3	100	0,055	- 0,055
2 087,8	100	0,085	0,035
2 092,9	100	0,115	0,005
2 097,9	100	0,145	0,035
2 100,5	100	0,175	0,005
2 105,5	100	0,025	0,005
2 108,0	100	0,025	- 0,025
2 115,6	100	- 0,005	0,035
2 120,7	100	- 0,035	0,005
2 123,2	100	- 0,065	0,005
2 125,7	100	- 0,095	0,005
2 129,9	100	0,025	0,005
2 132,5	100	0,025	0,035
2 142,6	100	0,055	- 0,055
2 150,2	100	0,085	0,035
2 155,2	100	0,115	0,005
2 160,3	100	0,145	0,035
2 162,8	100	0,175	0,005
2 167,8	100	0,025	0,005
2 170,4	100	0,025	- 0,025
2 177,9	100	- 0,005	0,035
2 180,5	100	- 0,035	0,005
2 183,0	100	- 0,065	0,005
2 186,4	100	0,025	0,005
2 188,9	100	0,025	0,035
2 199,0	100	0,055	- 0,055
2 206,6	100	0,085	0,035
2 211,6	100	0,115	0,005
2 214,2	100	0,145	0,005
2 218,4	100	0,025	0,005
2 220,9	100	0,025	- 0,025
2 228,5	100	- 0,005	0,035
2 231,0	100	- 0,035	0,005
2 233,5	100	0,025	0,005
2 236,1	100	0,025	0,035
2 246,2	100	0,055	- 0,055
2 253,7	100	0,085	0,035
2 258,8	100	0,115	0,005
2 261,3	100	0,145	0,005
2 265,5	100	0,025	0,005
2 268,1	100	0,025	- 0,025
2 275,6	100	- 0,005	0,035
2 278,2	100	- 0,035	0,005
2 280,7	100	0,025	0,005
2 283,2	100	0,025	0,035
2 293,3	100	0,055	- 0,055
2 300,9	100	0,085	0,035
2 306,0	100	0,115	0,005
2 308,5	100	0,145	0,005
2 312,7	100	0,025	0,005
2 315,2	100	0,025	- 0,025
2 322,8	100	- 0,005	0,035
2 325,3	100	- 0,035	0,005

2 327,8	100	0,025	0,005
2 330,4	100	0,025	0,035
2 340,5	100	0,055	- 0,055
2 348,1	100	0,085	0,035
2 353,1	100	0,115	0,005
2 355,6	100	0,145	0,005
2 359,9	100	0,025	0,005
2 362,4	100	0,025	- 0,025
2 370,0	100	- 0,005	0,035
2 372,5	100	- 0,035	0,005
2 375,0	100	0,025	0,005
2 377,5	100	0,025	0,035
2 385,1	100	0,055	- 0,025
2 392,7	100	0,085	0,035
2 397,7	100	0,115	0,005
2 400,3	100	0,145	0,005
2 404,5	100	0,025	0,005
2 407,0	100	0,025	- 0,025
2 412,1	100	- 0,005	0,035
2 414,6	100	- 0,035	0,005
2 417,1	100	0,025	0,005
2 419,6	100	0,025	0,035
2 427,2	100	0,055	- 0,025
2 434,8	100	0,085	0,035
2 439,9	100	0,115	0,005
2 442,4	100	0,145	0,005
2 446,6	100	0,025	0,005
2 449,1	100	0,025	- 0,025
2 454,2	100	- 0,005	0,035
2 456,7	100	- 0,035	0,005
2 459,2	100	0,025	0,005
2 461,8	100	0,025	0,035
2 469,3	100	0,055	- 0,025
2 476,9	100	0,085	0,035
2 482,0	100	0,115	0,005
2 484,5	100	0,145	0,005
2 488,7	100	0,025	0,005
2 491,2	100	0,025	- 0,025
2 496,3	100	- 0,005	0,035
2 498,8	100	- 0,035	0,005

2 501,3	100	0,025	0,005
2 503,9	100	0,025	0,035
2 511,4	100	0,055	- 0,025
2 519,0	100	0,085	0,035
2 524,1	100	0,115	0,005
2 526,6	100	0,145	0,005
2 530,8	100	0,025	0,005
2 533,3	100	0,025	- 0,025
2 538,4	100	- 0,005	0,035
2 540,9	100	- 0,035	0,005
2 543,4	100	0,025	0,005
2 546,0	100	0,025	0,035
2 553,5	100	0,055	- 0,025
2 561,1	100	0,085	0,035
2 563,7	100	0,115	0,005
2 566,2	100	0,145	0,005
2 570,4	100	0,025	0,005
2 572,9	100	0,025	- 0,025
2 578,0	100	- 0,005	0,035
2 580,5	100	- 0,035	0,005
2 583,0	100	0,025	0,005
2 585,5	100	0,025	0,035
2 593,1	100	0,055	- 0,025
2 600,7	100	0,085	0,035
2 603,2	100	0,115	0,005
2 606,6	100	0,025	0,005
2 609,1	100	0,025	- 0,025
2 614,2	100	- 0,005	0,035
2 616,7	100	- 0,035	0,005
2 619,2	100	0,025	0,005
2 621,8	100	0,025	0,035
2 629,3	100	0,055	- 0,025
2 636,9	100	0,085	0,035
2 639,4	100	0,115	0,005
2 642,8	100	0,025	0,005
2 645,3	100	0,025	- 0,025
2 650,4	100	- 0,005	0,035
2 652,1	100	0,025	0,005
2 654,6	100	0,025	0,035
2 662,2	100	0,055	- 0,025

2 669,8	100	0,085	0,035
2 672,3	100	0,115	0,005
2 675,7	100	0,025	0,005
2 678,2	100	0,025	- 0,025
2 683,2	100	- 0,005	0,035
2 684,9	100	0,025	0,005
2 687,4	100	0,025	0,035
2 695,0	100	0,055	- 0,025
2 702,6	100	0,085	0,035
2 705,1	100	0,115	0,005
2 708,5	100	0,025	0,005
2 711,0	100	0,025	- 0,025
2 716,1	100	- 0,005	0,035
2 717,8	100	0,025	0,005
2 720,3	100	0,025	0,035
2 727,9	100	0,055	- 0,025
2 735,5	100	0,085	0,035
2 738,0	100	0,115	0,005
2 741,3	100	0,025	0,005
2 743,9	100	0,025	- 0,025
2 748,9	100	- 0,005	0,035
2 750,6	100	0,025	0,005
2 753,1	100	0,025	0,035
2 760,7	100	0,055	- 0,025
2 765,8	100	0,085	0,035
2 768,3	100	0,115	0,005
2 771,7	100	0,025	0,005
2 774,2	100	0,025	- 0,025
2 779,2	100	- 0,005	0,035
2 780,9	100	0,025	0,005
2 783,5	100	0,025	0,035
2 791,0	100	0,055	- 0,025
2 796,1	100	0,085	0,035
2 798,6	100	0,115	0,005
2 802,0	100	0,025	0,005
2 804,5	100	0,025	- 0,025
2 809,6	100	- 0,005	0,035
2 811,2	100	0,025	0,005
2 813,8	100	0,025	0,035
2 821,4	100	0,055	- 0,025
2 826,4	100	0,085	0,035
2 828,9	100	0,115	0,005
2 832,3	100	0,025	0,005
2 834,8	100	0,025	- 0,025
2 839,9	100	- 0,005	0,035
2 841,6	100	0,025	0,005
2 844,1	100	0,025	0,035
2 851,7	100	0,055	- 0,025
2 856,7	100	0,085	0,035
2 859,2	100	0,115	0,005
2 862,6	100	0,025	0,005
2 865,1	100	0,025	- 0,025
2 870,2	100	- 0,005	0,035
2 871,9	100	0,025	0,005
2 874,4	100	0,025	0,035
2 882,0	100	0,055	- 0,025
2 887,0	100	0,085	0,035
2 889,6	100	0,115	0,005
2 892,9	100	0,025	0,005
2 895,5	100	0,025	- 0,025
2 900,5	100	- 0,005	0,035
2 902,2	100	0,025	0,005
2 904,7	100	0,025	0,035
2 912,3	100	0,055	- 0,025
2 917,4	100	0,085	0,035
2 919,9	100	0,115	0,005
2 923,3	100	0,025	0,005
2 925,8	100	0,025	- 0,025
2 930,8	100	- 0,005	0,035
2 932,5	100	0,025	0,005
2 935,0	100	0,025	0,035
2 942,6	100	0,055	- 0,025
2 947,7	100	0,085	0,035
2 950,2	100	0,025	0,005
2 952,7	100	0,025	- 0,025
2 957,8	100	- 0,005	0,035
2 959,5	100	0,025	0,005
2 962,0	100	0,025	0,035
2 969,6	100	0,055	- 0,025
2 974,6	100	0,085	0,035

2 977,2	100	0,025	0,005
2 979,7	100	0,025	- 0,025
2 984,7	100	- 0,005	0,035
2 986,4	100	0,025	0,005
2 988,9	100	0,025	0,035
2 996,5	100	0,055	- 0,025
3 001,6	100	0,085	0,035
3 004,1	100	0,025	0,005
3 006,6	100	0,025	- 0,025
3 011,7	100	- 0,005	0,035
3 013,4	100	0,025	0,005
3 015,9	100	0,025	0,035
3 023,5	100	0,055	- 0,025
3 028,5	100	0,085	0,035
3 031,0	100	0,025	0,005
3 036,1	100	0,025	0,005
3 041,2	100	- 0,005	0,035
3 042,8	100	0,025	0,005
3 045,4	100	0,025	0,035
3 052,9	100	0,055	- 0,025
3 058,0	100	0,085	0,035
3 060,5	100	0,025	0,005
3 065,6	100	0,025	0,005
3 070,6	100	- 0,005	0,035
3 072,3	100	0,025	0,005
3 074,8	100	0,025	0,035
3 082,4	100	0,055	- 0,025
3 087,5	100	0,085	0,035
3 090,0	100	0,025	0,005
3 095,1	100	0,025	0,005
3 100,1	100	- 0,005	0,035
3 101,8	100	0,025	0,005
3 104,3	100	0,025	0,035
3 111,9	100	0,055	- 0,025
3 116,9	100	0,085	0,035
3 119,5	100	0,025	0,005
3 124,5	100	0,025	0,005
3 129,6	100	- 0,005	0,035
3 131,3	100	0,025	0,005
3 133,8	100	0,025	0,035
3 141,4	100	0,055	- 0,025
3 146,4	100	0,085	0,035
3 149,0	100	0,025	0,005
3 154,0	100	0,025	0,005
3 159,1	100	- 0,005	0,035
3 160,7	100	0,025	0,005
3 163,3	100	0,025	0,035
3 170,8	100	0,055	- 0,025
3 175,9	100	0,085	0,035
3 178,4	100	0,025	0,005
3 183,5	100	0,025	0,005
3 188,5	100	- 0,005	0,035
3 190,2	100	0,025	0,005
3 192,7	100	0,025	0,035
3 197,8	100	0,055	0,005
3 202,8	100	0,085	0,035
3 205,4	100	0,025	0,005
3 210,4	100	0,025	0,005
3 215,5	100	- 0,005	0,035
3 217,2	100	0,025	0,005
3 219,7	100	0,025	0,035
3 224,7	100	0,055	0,005
3 229,8	100	0,085	0,035
3 232,3	100	0,025	0,005
3 237,4	100	0,025	0,005
3 242,4	100	- 0,005	0,035
3 244,1	100	0,025	0,005
3 246,6	100	0,025	0,035
3 251,7	100	0,055	0,005
3 256,7	100	0,085	0,035
3 259,3	100	0,025	0,005
3 264,3	100	0,025	0,005
3 269,4	100	- 0,005	0,035
3 271,1	100	0,025	0,005
3 273,6	100	0,025	0,035
3 278,6	100	0,055	0,005
3 283,7	100	0,085	0,035
3 286,2	100	0,025	0,005
3 291,3	100	0,025	0,005
3 296,3	100	- 0,005	0,035

3 298,0	100	0,025	0,005
3 300,5	100	0,025	0,035
3 305,6	100	0,055	0,005
3 310,6	100	0,085	0,035
3 313,2	100	0,025	0,005
3 318,2	100	0,025	0,005
3 323,3	100	- 0,005	0,035
3 325,0	100	0,025	0,005
3 327,5	100	0,025	0,035
3 332,5	100	0,055	0,005
3 335,1	100	0,085	0,005
3 337,6	100	0,025	0,005
3 342,6	100	0,025	0,005
3 347,7	100	- 0,005	0,035
3 349,4	100	0,025	0,005
3 351,9	100	0,025	0,035
3 357,0	100	0,055	0,005
3 359,5	100	0,085	0,005
3 362,0	100	0,025	0,005
3 367,1	100	0,025	0,005
3 372,1	100	- 0,005	0,035
3 373,8	100	0,025	0,005
3 376,3	100	0,025	0,035
3 381,4	100	0,055	0,005
3 383,9	100	0,085	0,005
3 386,4	100	0,025	0,005
3 391,5	100	0,025	0,005
3 394,0	100	- 0,005	0,005
3 395,7	100	0,025	0,005
3 398,2	100	0,025	0,035
3 403,3	100	0,055	0,005
3 405,8	100	0,085	0,005
3 408,3	100	0,025	0,005
3 413,4	100	0,025	0,005
3 415,9	100	- 0,005	0,005
3 417,6	100	0,025	0,005
3 420,1	100	0,025	0,035
3 425,2	100	0,055	0,005
3 427,7	100	0,085	0,005
3 430,2	100	0,025	0,005
3 435,3	100	0,025	0,005
3 437,8	100	- 0,005	0,005
3 439,5	100	0,025	0,005
3 442,0	100	0,025	0,035
3 447,1	100	0,055	0,005
3 449,6	100	0,085	0,005
3 452,1	100	0,025	0,005
3 457,2	100	0,025	0,005
3 459,7	100	- 0,005	0,005
3 461,4	100	0,025	0,005
3 463,9	100	0,025	0,035
3 469,0	100	0,055	0,005
3 471,5	100	0,085	0,005
3 474,0	100	0,025	0,005
3 479,1	100	0,025	0,005
3 481,6	100	- 0,005	0,005
3 483,3	100	0,025	0,005
3 485,8	100	0,025	0,035
3 490,9	100	0,055	0,005
3 493,4	100	0,085	0,005
3 495,9	100	0,025	0,005
3 501,0	100	0,025	0,005
3 503,5	100	- 0,005	0,005
3 505,2	100	0,025	0,005
3 507,7	100	0,025	0,035
3 512,8	100	0,055	0,005
3 515,3	100	0,085	0,005
3 517,8	100	0,025	0,005
3 522,9	100	0,025	0,005
3 525,4	100	- 0,005	0,005
3 527,1	100	0,025	0,005
3 529,6	100	0,025	0,035
3 534,7	100	0,055	0,005
3 537,2	100	0,085	0,005
3 539,7	100	0,025	0,005
3 544,8	100	0,025	0,005
3 547,3	100	- 0,005	0,005
3 549,0	100	0,025	0,005
3 551,5	100	0,025	0,035
3 556,6	100	0,055	0,005

3 559,1	100	0,085	0,005
3 561,6	100	0,025	0,005
3 566,7	100	0,025	0,005
3 569,2	100	- 0,005	0,005
3 570,9	100	0,025	0,005
3 573,4	100	0,025	0,035
3 578,5	100	0,055	0,005
3 581,0	100	0,085	0,005
3 583,5	100	0,025	0,005
3 588,6	100	0,025	0,005
3 591,1	100	- 0,005	0,005
3 592,8	100	0,025	0,005
3 595,3	100	0,025	0,035
3 600,3	100	0,055	0,005
3 602,9	100	0,085	0,005
3 605,4	100	0,025	0,005
3 610,5	100	0,025	0,005
3 613,0	100	- 0,005	0,005
3 614,7	100	0,025	0,005
3 617,2	100	0,025	0,035
3 619,7	100	0,055	0,005
3 622,2	100	0,085	0,005
3 624,8	100	0,025	0,005
3 629,8	100	0,025	0,005
3 632,3	100	- 0,005	0,005
3 634,0	100	0,025	0,005
3 636,6	100	0,025	0,035
3 639,1	100	0,055	0,005
3 641,6	100	0,085	0,005
3 644,1	100	0,025	0,005
3 649,2	100	0,025	0,005
3 651,7	100	- 0,005	0,005
3 653,4	100	0,025	0,005
3 655,9	100	0,025	0,035
3 658,5	100	0,055	0,005
3 661,0	100	0,085	0,005
3 663,5	100	0,025	0,005
3 668,6	100	0,025	0,005
3 671,1	100	- 0,005	0,005
3 672,8	100	0,025	0,005
3 675,3	100	0,025	0,035
3 677,8	100	0,055	0,005
3 680,4	100	0,085	0,005
3 682,9	100	0,025	0,005
3 687,9	100	0,025	0,005
3 690,5	100	- 0,005	0,005
3 692,1	100	0,025	0,005
3 694,7	100	0,025	0,035
3 697,2	100	0,055	0,005
3 699,7	100	0,085	0,005
3 702,2	100	0,025	0,005
3 707,3	100	0,025	0,005
3 709,8	100	- 0,005	0,005
3 711,5	100	0,025	0,005
3 714,0	100	0,025	0,035
3 716,6	100	0,055	0,005
3 719,1	100	0,085	0,005
3 721,6	100	0,025	0,005
3 726,7	100	0,025	0,005
3 729,2	100	- 0,005	0,005
3 730,9	100	0,025	0,005
3 733,4	100	0,025	0,035
3 735,9	100	0,055	0,005
3 738,5	100	0,085	0,005
3 741,0	100	0,025	0,005
3 746,0	100	0,025	0,005
3 748,6	100	- 0,005	0,005
3 750,3	100	0,025	0,005
3 752,8	100	0,025	0,035
3 755,3	100	0,055	0,005
3 757,8	100	0,085	0,005
3 760,4	100	0,025	0,005
3 765,4	100	0,025	0,005
3 767,9	100	- 0,005	0,005
3 769,6	100	0,025	0,005
3 772,1	100	0,025	0,035
3 774,7	100	0,055	0,005
3 777,2	100	0,085	0,005
3 779,7	100	0,025	0,005
3 784,8	100	0,025	0,005

3 787,3	100	- 0,005	0,005
3 789,0	100	0,025	0,005
3 791,5	100	0,025	0,035
3 794,0	100	0,055	0,005
3 796,6	100	0,085	0,005
3 799,1	100	0,025	0,005
3 804,1	100	0,025	0,005
3 806,7	100	- 0,005	0,005
3 808,4	100	0,025	0,005
3 810,9	100	0,025	0,035
3 813,4	100	0,055	0,005
3 815,9	100	0,085	0,005
3 818,5	100	0,025	0,005
3 823,5	100	0,025	0,005
3 826,0	100	- 0,005	0,005
3 827,7	100	0,025	0,005
3 830,3	100	0,025	0,035
3 832,8	100	0,055	0,005
3 835,3	100	0,085	0,005
3 837,8	100	0,025	0,005
3 842,9	100	0,025	0,005
3 845,4	100	- 0,005	0,005
3 847,1	100	0,025	0,005
3 849,6	100	0,025	0,035
3 852,2	100	0,055	0,005
3 854,7	100	0,085	0,005
3 857,2	100	0,025	0,005
3 862,3	100	0,025	0,005
3 864,8	100	- 0,005	0,005
3 866,5	100	0,025	0,005
3 869,0	100	0,025	0,035
3 871,5	100	0,055	0,005
3 873,2	100	0,025	0,005
3 878,3	100	0,025	0,005
3 880,8	100	- 0,005	0,005
3 882,5	100	0,025	0,005
3 885,0	100	0,025	0,035
3 887,5	100	0,055	0,005
3 889,2	100	0,025	0,005
3 894,3	100	0,025	0,005
3 896,8	100	- 0,005	0,005
3 898,5	100	0,025	0,005
3 901,0	100	0,025	0,035
3 903,5	100	0,055	0,005
3 905,2	100	0,025	0,005
3 910,3	100	0,025	0,005
3 912,8	100	- 0,005	0,005
3 914,5	100	0,025	0,005
3 917,0	100	0,025	0,035
3 919,5	100	0,055	0,005
3 921,2	100	0,025	0,005
3 926,3	100	0,025	0,005
3 928,8	100	- 0,005	0,005
3 930,5	100	0,025	0,005
3 933,0	100	0,025	0,035
3 935,5	100	0,055	0,005
3 937,2	100	0,025	0,005
3 942,3	100	0,025	0,005
3 944,8	100	- 0,005	0,005
3 946,5	100	0,025	0,005
3 951,5	100	0,025	0,005
3 954,1	100	0,055	0,005
3 955,7	100	0,025	0,005
3 960,8	100	0,025	0,005
3 963,3	100	- 0,005	0,005
3 965,0	100	0,025	0,005
4 015,0	60	0,000	0,000
5 188,3	60	0,025	0,005
5 221,7	60	0,025	0,365
5 291,3	60	0,055	- 0,355
5 358,1	60	0,085	0,335
5 416,6	60	0,115	- 0,325
5 458,3	60	0,145	0,245
5 486,2	60	0,175	- 0,085
5 497,3	60	0,205	0,065
5 505,6	60	0,235	- 0,025
5 511,2	60	0,265	0,035
5 514,0	60	0,295	0,005
5 523,3	60	0,025	0,005
5 562,2	60	0,025	- 0,415

5 637,4	60	- 0,005	0,365
5 693,1	60	- 0,035	- 0,235
5 737,6	60	- 0,065	0,215
5 779,3	60	- 0,095	- 0,235
5 801,6	60	- 0,125	0,095
5 818,3	60	- 0,155	- 0,055
5 826,7	60	- 0,185	0,035
5 835,0	60	- 0,215	- 0,025
5 837,8	60	- 0,245	0,005
5 847,1	60	0,025	0,005
5 877,7	60	0,025	0,335
5 941,7	60	0,055	- 0,325
5 991,8	60	0,085	0,275
6 033,6	60	0,115	- 0,175
6 047,5	60	0,145	0,065
6 055,8	60	0,175	- 0,025
6 061,4	60	0,205	0,035
6 067,0	60	0,235	0,005
6 074,4	60	0,025	0,005
6 107,8	60	0,025	- 0,355
6 169,0	60	- 0,005	0,335
6 202,4	60	- 0,035	- 0,175
6 227,5	60	- 0,065	0,095
6 246,9	60	- 0,095	- 0,085
6 258,1	60	- 0,125	0,065
6 266,4	60	- 0,155	- 0,025
6 269,2	60	- 0,185	0,005
6 276,6	60	0,025	0,005
6 307,3	60	0,025	0,335
6 360,1	60	0,055	- 0,265
6 404,7	60	0,085	0,245
6 429,7	60	0,115	- 0,085
6 440,9	60	0,145	0,035
6 446,4	60	0,175	0,005
6 452,0	60	0,205	0,035
6 454,8	60	0,235	0,005
6 462,2	60	0,025	0,005
6 490,0	60	0,025	- 0,295
6 542,9	60	- 0,005	0,275
6 562,4	60	- 0,035	- 0,085
6 576,3	60	- 0,065	0,065
6 587,4	60	- 0,095	- 0,055
6 595,8	60	- 0,125	0,035
6 601,4	60	- 0,155	0,005
6 604,1	60	- 0,185	0,005
6 611,6	60	0,025	0,005
6 636,6	60	0,025	0,275
6 686,7	60	0,055	- 0,235
6 725,7	60	0,085	0,215
6 739,6	60	0,115	- 0,055
6 745,2	60	0,145	0,035
6 750,7	60	0,175	0,005
6 753,5	60	0,205	0,005
6 760,0	60	0,025	0,005
6 785,1	60	0,025	- 0,265
6 835,2	60	- 0,005	0,275
6 849,1	60	- 0,035	- 0,055
6 857,4	60	- 0,065	0,035
6 865,8	60	- 0,095	- 0,025
6 871,3	60	- 0,125	0,035
6 874,1	60	- 0,155	0,005
6 880,6	60	0,025	0,005
6 905,7	60	0,025	0,275
6 950,2	60	0,055	- 0,205
6 983,6	60	0,085	0,185
6 994,7	60	0,115	- 0,025
7 000,3	60	0,145	0,035
7 005,9	60	0,175	0,005
7 008,7	60	0,205	0,005
7 015,2	60	0,025	0,005
7 040,2	60	0,025	- 0,265
7 082,0	60	- 0,005	0,215
7 093,1	60	- 0,035	- 0,025
7 101,4	60	- 0,065	0,035
7 109,8	60	- 0,095	- 0,025
7 115,4	60	- 0,125	0,035
7 118,1	60	- 0,155	0,005
7 124,6	60	0,025	0,005
7 146,9	60	0,025	0,245
7 185,9	60	0,055	- 0,175

7 213,7	60	0,085	0,155
7 224,8	60	0,115	- 0,025
7 230,4	60	0,145	0,035
7 233,2	60	0,175	0,005
7 238,7	60	0,025	0,005
7 261,0	60	0,025	- 0,235
7 297,2	60	- 0,005	0,185
7 305,5	60	- 0,035	- 0,025
7 313,9	60	- 0,065	0,035
7 319,5	60	- 0,095	0,005
7 325,0	60	- 0,125	0,035
7 327,8	60	- 0,155	0,005
7 334,3	60	0,025	0,005
7 353,8	60	0,025	0,215
7 392,8	60	0,055	- 0,175
7 412,2	60	0,085	0,095
7 420,6	60	0,115	- 0,025
7 426,2	60	0,145	0,035
7 428,9	60	0,175	0,005
7 434,5	60	0,025	0,005
7 454,0	60	0,025	- 0,205
7 490,2	60	- 0,005	0,185
7 498,5	60	- 0,035	- 0,025
7 506,9	60	- 0,065	0,035
7 512,4	60	- 0,095	0,005
7 515,2	60	- 0,125	0,005
7 520,8	60	0,025	0,005
7 540,3	60	0,025	0,215
7 576,5	60	0,055	- 0,175
7 595,9	60	0,085	0,095
7 601,5	60	0,115	0,005
7 607,1	60	0,145	0,035
7 609,9	60	0,175	0,005
7 615,4	60	0,025	0,005
7 634,9	60	0,025	- 0,205
7 665,5	60	- 0,005	0,155
7 673,9	60	- 0,035	- 0,025
7 679,4	60	- 0,065	0,035
7 685,0	60	- 0,095	0,005
7 687,8	60	- 0,125	0,005
7 693,4	60	0,025	0,005
7 712,8	60	0,025	0,215
7 749,0	60	0,055	- 0,175
7 765,7	60	0,085	0,095
7 771,3	60	0,115	0,005
7 774,1	60	0,145	0,005
7 776,9	60	0,175	0,005
7 782,4	60	0,025	0,005
7 801,9	60	0,025	- 0,205
7 832,5	60	- 0,005	0,155
7 840,9	60	- 0,035	- 0,025
7 846,4	60	- 0,065	0,035
7 849,2	60	- 0,095	0,005
7 852,0	60	- 0,125	0,005
7 857,6	60	0,025	0,005
7 877,1	60	0,025	0,215
7 910,5	60	0,055	- 0,145
7 924,4	60	0,085	0,065
7 929,9	60	0,115	0,005
7 932,7	60	0,145	0,005
7 937,4	60	0,025	0,005
7 954,1	60	0,025	- 0,175
7 984,7	60	- 0,005	0,155
7 993,0	60	- 0,035	- 0,025
7 998,6	60	- 0,065	0,035
8 001,4	60	- 0,095	0,005
8 004,2	60	- 0,125	0,005
8 009,7	60	0,025	0,005
8 026,4	60	0,025	0,185
8 057,1	60	0,055	- 0,145
8 068,2	60	0,085	0,065
8 073,8	60	0,115	0,005
8 076,5	60	0,145	0,005
8 081,2	60	0,025	0,005
8 097,9	60	0,025	- 0,175
8 122,9	60	- 0,005	0,125
8 128,5	60	- 0,035	0,005
8 134,1	60	- 0,065	0,035
8 136,8	60	- 0,095	0,005
8 139,6	60	- 0,125	0,005

8 145,2	60	0,025	0,005
8 161,9	60	0,025	0,185
8 192,5	60	0,055	- 0,145
8 203,6	60	0,085	0,065
8 209,2	60	0,115	0,005
8 212,0	60	0,145	0,005
8 216,6	60	0,025	0,005
8 233,3	60	0,025	- 0,175
8 255,6	60	- 0,005	0,125
8 261,2	60	- 0,035	0,005
8 266,7	60	- 0,065	0,035
8 269,5	60	- 0,095	0,005
8 272,3	60	- 0,125	0,005
8 277,9	60	0,025	0,005
8 294,6	60	0,025	0,185
8 322,4	60	0,055	- 0,115
8 333,5	60	0,085	0,065
8 339,1	60	0,115	0,005
8 341,9	60	0,145	0,005
8 346,5	60	0,025	0,005
8 360,4	60	0,025	- 0,145
8 382,7	60	- 0,005	0,125
8 388,3	60	- 0,035	0,005
8 391,1	60	- 0,065	0,005
8 393,8	60	- 0,095	0,005
8 398,5	60	0,025	0,005
8 415,2	60	0,025	0,185
8 440,2	60	0,055	- 0,115
8 451,4	60	0,085	0,065
8 456,9	60	0,115	0,005
8 460,6	60	0,025	0,005
8 474,6	60	0,025	- 0,145
8 494,0	60	- 0,005	0,095
8 499,6	60	- 0,035	0,005
8 502,4	60	- 0,065	0,005
8 505,2	60	- 0,095	0,005
8 509,8	60	0,025	0,005
8 523,7	60	0,025	0,155
8 548,8	60	0,055	- 0,115
8 557,1	60	0,085	0,035
8 562,7	60	0,115	0,005
8 566,4	60	0,025	0,005
8 580,3	60	0,025	- 0,145
8 599,8	60	- 0,005	0,095
8 605,4	60	- 0,035	0,005
8 608,2	60	- 0,065	0,005
8 610,9	60	- 0,095	0,005
8 615,6	60	0,025	0,005
8 629,5	60	0,025	0,155
8 654,5	60	0,055	- 0,115
8 662,9	60	0,085	0,035
8 665,7	60	0,115	0,005
8 669,4	60	0,025	0,005
8 683,3	60	0,025	- 0,145
8 702,8	60	- 0,005	0,095
8 708,4	60	- 0,035	0,005
8 711,1	60	- 0,065	0,005
8 713,9	60	- 0,095	0,005
8 718,6	60	0,025	0,005
8 732,5	60	0,025	0,155
8 752,0	60	0,055	- 0,085
8 760,3	60	0,085	0,035
8 763,1	60	0,115	0,005
8 766,8	60	0,025	0,005
8 780,7	60	0,025	- 0,145
8 797,4	60	- 0,005	0,095
8 800,2	60	- 0,035	0,005
8 803,0	60	- 0,065	0,005
8 806,7	60	0,025	0,005
8 820,6	60	0,025	0,155
8 840,1	60	0,055	- 0,085
8 848,5	60	0,085	0,035
8 851,2	60	0,115	0,005
8 854,9	60	0,025	0,005
8 866,1	60	0,025	- 0,115
8 882,8	60	- 0,005	0,095
8 885,6	60	- 0,035	0,005
8 888,3	60	- 0,065	0,005
8 892,1	60	0,025	0,005
8 906,0	60	0,025	0,155

8 925,5	60	0,055	- 0,085
8 933,8	60	0,085	0,035
8 936,6	60	0,115	0,005
8 940,3	60	0,025	0,005
8 951,4	60	0,025	- 0,115
8 968,1	60	- 0,005	0,095
8 970,9	60	- 0,035	0,005
8 973,7	60	- 0,065	0,005
8 977,4	60	0,025	0,005
8 988,5	60	0,025	0,125
9 008,0	60	0,055	- 0,085
9 013,6	60	0,085	0,035
9 016,4	60	0,115	0,005
9 020,1	60	0,025	0,005
9 031,2	60	0,025	- 0,115
9 045,1	60	- 0,005	0,065
9 047,9	60	- 0,035	0,005
9 050,7	60	- 0,065	0,005
9 054,4	60	0,025	0,005
9 065,6	60	0,025	0,125
9 085,0	60	0,055	- 0,085
9 090,6	60	0,085	0,035
9 093,4	60	0,115	0,005
9 097,1	60	0,025	0,005
9 108,2	60	0,025	- 0,115
9 122,1	60	- 0,005	0,065
9 124,9	60	- 0,035	0,005
9 127,7	60	- 0,065	0,005
9 131,4	60	0,025	0,005
9 142,6	60	0,025	0,125
9 162,0	60	0,055	- 0,085
9 167,6	60	0,085	0,035
9 170,4	60	0,115	0,005
9 174,1	60	0,025	0,005
9 185,2	60	0,025	- 0,115
9 199,2	60	- 0,005	0,065
9 201,9	60	- 0,035	0,005
9 204,7	60	0,025	0,005
9 215,9	60	0,025	0,125
9 235,3	60	0,055	- 0,085
9 240,9	60	0,085	0,035
9 243,7	60	0,025	0,005
9 254,8	60	0,025	- 0,115
9 268,7	60	- 0,005	0,065
9 271,5	60	- 0,035	0,005
9 274,3	60	0,025	0,005
9 282,7	60	0,025	0,095
9 299,4	60	0,055	- 0,055
9 304,9	60	0,085	0,035
9 307,7	60	0,025	0,005
9 318,8	60	0,025	- 0,115
9 332,8	60	- 0,005	0,065
9 335,5	60	- 0,035	0,005
9 338,3	60	0,025	0,005
9 346,7	60	0,025	0,095
9 363,4	60	0,055	- 0,055
9 368,9	60	0,085	0,035
9 371,7	60	0,025	0,005
9 380,1	60	0,025	- 0,085
9 394,0	60	- 0,005	0,065
9 396,8	60	- 0,035	0,005
9 399,6	60	0,025	0,005
9 407,9	60	0,025	0,095
9 421,8	60	0,055	- 0,055
9 427,4	60	0,085	0,035
9 430,2	60	0,025	0,005
9 438,5	60	0,025	- 0,085
9 449,7	60	- 0,005	0,065
9 452,4	60	- 0,035	0,005
9 455,2	60	0,025	0,005
9 463,6	60	0,025	0,095
9 477,5	60	0,055	- 0,055
9 483,1	60	0,085	0,035
9 485,8	60	0,025	0,005
9 494,2	60	0,025	- 0,085
9 505,3	60	- 0,005	0,065
9 508,1	60	- 0,035	0,005
9 510,9	60	0,025	0,005
9 519,2	60	0,025	0,095
9 533,2	60	0,055	- 0,055

9 538,7	60	0,085	0,035
9 541,5	60	0,025	0,005
9 549,9	60	0,025	- 0,085
9 561,0	60	- 0,005	0,065
9 563,8	60	- 0,035	0,005
9 566,6	60	0,025	0,005
9 574,9	60	0,025	0,095
9 588,8	60	0,055	- 0,055
9 594,4	60	0,085	0,035
9 597,2	60	0,025	0,005
9 605,5	60	0,025	- 0,085
9 616,7	60	- 0,005	0,065
9 619,4	60	- 0,035	0,005
9 622,2	60	0,025	0,005
9 630,6	60	0,025	0,095
9 644,5	60	0,055	- 0,055
9 650,1	60	0,085	0,035
9 652,8	60	0,025	0,005
9 661,2	60	0,025	- 0,085
9 669,5	60	- 0,005	0,035
9 672,3	60	- 0,035	0,005
9 675,1	60	0,025	0,005
9 683,5	60	0,025	0,095
9 697,4	60	0,055	- 0,055
9 700,2	60	0,085	0,005
9 702,9	60	0,025	0,005
9 708,5	60	0,025	- 0,055
9 716,9	60	- 0,005	0,035
9 719,6	60	- 0,035	0,005
9 722,4	60	0,025	0,005
9 730,8	60	0,025	0,095
9 744,7	60	0,055	- 0,055
9 747,5	60	0,085	0,005
9 750,3	60	0,025	0,005
9 755,8	60	0,025	- 0,055
9 764,2	60	- 0,005	0,035
9 767,0	60	- 0,035	0,005
9 769,7	60	0,025	0,005
9 778,1	60	0,025	0,095
9 792,0	60	0,055	- 0,055
9 794,8	60	0,085	0,005
9 797,6	60	0,025	0,005
9 803,1	60	0,025	- 0,055
9 811,5	60	- 0,005	0,035
9 814,3	60	- 0,035	0,005
9 817,1	60	0,025	0,005
9 825,4	60	0,025	0,095
9 839,3	60	0,055	- 0,055
9 842,1	60	0,085	0,005
9 844,9	60	0,025	0,005
9 850,5	60	0,025	- 0,055
9 858,8	60	- 0,005	0,035
9 861,6	60	- 0,035	0,005
9 864,4	60	0,025	0,005
9 869,9	60	0,025	0,065
9 883,9	60	0,055	- 0,055
9 886,6	60	0,085	0,005
9 889,4	60	0,025	0,005
9 895,0	60	0,025	- 0,055
9 903,3	60	- 0,005	0,035
9 906,1	60	- 0,035	0,005
9 908,9	60	0,025	0,005
9 914,5	60	0,025	0,065
9 925,6	60	0,055	- 0,025
9 928,4	60	0,085	0,005
9 931,2	60	0,025	0,005
9 936,7	60	0,025	- 0,055
9 945,1	60	- 0,005	0,035
9 947,9	60	- 0,035	0,005
9 950,7	60	0,025	0,005
9 956,2	60	0,025	0,065
9 967,4	60	0,055	- 0,025
9 970,1	60	0,085	0,005
9 972,9	60	0,025	0,005
9 978,5	60	0,025	- 0,055
9 986,8	60	- 0,005	0,035
9 989,6	60	- 0,035	0,005
9 992,4	60	0,025	0,005
9 998,0	60	0,025	0,065
10 009,1	60	0,055	- 0,025

10 011,9	60	0,085	0,005
10 014,7	60	0,025	0,005
10 020,2	60	0,025	- 0,055
10 028,6	60	- 0,005	0,035
10 030,4	60	0,025	0,005
10 036,0	60	0,025	0,065
10 047,1	60	0,055	- 0,025
10 049,9	60	0,085	0,005
10 052,7	60	0,025	0,005
10 058,3	60	0,025	- 0,055
10 066,6	60	- 0,005	0,035
10 068,5	60	0,025	0,005
10 074,1	60	0,025	0,065
10 085,2	60	0,055	- 0,025
10 088,0	60	0,085	0,005
10 090,8	60	0,025	0,005
10 096,3	60	0,025	- 0,055
10 104,7	60	- 0,005	0,035
10 106,5	60	0,025	0,005
10 112,1	60	0,025	0,065
10 123,2	60	0,055	- 0,025
10 126,0	60	0,085	0,005
10 128,8	60	0,025	0,005
10 134,4	60	0,025	- 0,055
10 142,7	60	- 0,005	0,035
10 144,6	60	0,025	0,005
10 150,1	60	0,025	0,065
10 161,3	60	0,055	- 0,025
10 164,0	60	0,085	0,005
10 166,8	60	0,025	0,005
10 172,4	60	0,025	- 0,055
10 180,7	60	- 0,005	0,035
10 182,6	60	0,025	0,005
10 188,2	60	0,025	0,065
10 196,5	60	0,055	- 0,025
10 199,3	60	0,085	0,005
10 202,1	60	0,025	0,005
10 207,7	60	0,025	- 0,055
10 216,0	60	- 0,005	0,035
10 217,9	60	0,025	0,005
10 223,4	60	0,025	0,065
10 231,8	60	0,055	- 0,025
10 234,6	60	0,085	0,005
10 237,3	60	0,025	0,005
10 242,9	60	0,025	- 0,055
10 251,3	60	- 0,005	0,035
10 253,1	60	0,025	0,005
10 258,7	60	0,025	0,065
10 267,0	60	0,055	- 0,025
10 269,8	60	0,085	0,005
10 272,6	60	0,025	0,005
10 278,2	60	0,025	- 0,055
10 286,5	60	- 0,005	0,035
10 288,4	60	0,025	0,005
10 293,9	60	0,025	0,065
10 302,3	60	0,055	- 0,025
10 305,1	60	0,085	0,005
10 307,9	60	0,025	0,005
10 313,4	60	0,025	- 0,055
10 321,8	60	- 0,005	0,035
10 323,6	60	0,025	0,005
10 329,2	60	0,025	0,065
10 337,5	60	0,055	- 0,025
10 340,3	60	0,085	0,005
10 343,1	60	0,025	0,005
10 348,7	60	0,025	- 0,055
10 357,0	60	- 0,005	0,035
10 358,9	60	0,025	0,005
10 364,4	60	0,025	0,065
10 372,8	60	0,055	- 0,025
10 375,6	60	0,085	0,005
10 378,4	60	0,025	0,005
10 383,9	60	0,025	- 0,055
10 392,3	60	- 0,005	0,035
10 394,1	60	0,025	0,005
10 399,7	60	0,025	0,065
10 408,1	60	0,055	- 0,025
10 410,8	60	0,085	0,005
10 413,6	60	0,025	0,005
10 419,2	60	0,025	- 0,055

10 427,5	60	- 0,005	0,035
10 429,4	60	0,025	0,005
10 435,0	60	0,025	0,065
10 443,3	60	0,055	- 0,025
10 446,1	60	0,085	0,005
10 448,9	60	0,025	0,005
10 454,4	60	0,025	- 0,055
10 462,8	60	- 0,005	0,035
10 464,6	60	0,025	0,005
10 470,2	60	0,025	0,065
10 478,6	60	0,055	- 0,025
10 481,3	60	0,085	0,005
10 484,1	60	0,025	0,005
10 489,7	60	0,025	- 0,055
10 498,0	60	- 0,005	0,035
10 499,9	60	0,025	0,005
10 505,5	60	0,025	0,065
10 513,8	60	0,055	- 0,025
10 516,6	60	0,085	0,005
10 519,4	60	0,025	0,005
10 525,0	60	0,025	- 0,055
10 533,3	60	- 0,005	0,035
10 535,2	60	0,025	0,005
10 540,7	60	0,025	0,065
10 549,1	60	0,055	- 0,025
10 551,9	60	0,085	0,005
10 554,6	60	0,025	0,005
10 560,2	60	0,025	- 0,055
10 568,6	60	- 0,005	0,035
10 570,4	60	0,025	0,005
10 576,0	60	0,025	0,065
10 584,3	60	0,055	- 0,025
10 586,2	60	0,025	0,005
10 589,0	60	0,025	- 0,025
10 597,3	60	- 0,005	0,035
10 599,2	60	0,025	0,005
10 604,7	60	0,025	0,065
10 613,1	60	0,055	- 0,025
10 615,0	60	0,025	0,005
10 617,7	60	0,025	- 0,025
10 626,1	60	- 0,005	0,035
10 627,9	60	0,025	0,005
10 633,5	60	0,025	0,065
10 641,9	60	0,055	- 0,025
10 643,7	60	0,025	0,005
10 646,5	60	0,025	- 0,025
10 654,8	60	- 0,005	0,035
10 656,7	60	0,025	0,005
10 662,3	60	0,025	0,065
10 670,6	60	0,055	- 0,025
10 672,5	60	0,025	0,005
10 675,3	60	0,025	- 0,025
10 683,6	60	- 0,005	0,035
10 685,5	60	0,025	0,005
10 691,0	60	0,025	0,065
10 699,4	60	0,055	- 0,025
10 701,2	60	0,025	0,005
10 704,0	60	0,025	- 0,025
10 712,4	60	- 0,005	0,035
10 714,2	60	0,025	0,005
10 719,8	60	0,025	0,065
10 728,1	60	0,055	- 0,025
10 730,0	60	0,025	0,005
10 732,8	60	0,025	- 0,025
10 741,1	60	- 0,005	0,035
10 743,0	60	0,025	0,005
10 748,6	60	0,025	0,065
10 756,9	60	0,055	- 0,025
10 758,8	60	0,025	0,005
10 761,5	60	0,025	- 0,025
10 769,9	60	- 0,005	0,035
10 771,7	60	0,025	0,005
10 777,3	60	0,025	0,065
10 785,7	60	0,055	- 0,025
10 787,5	60	0,025	0,005
10 790,3	60	0,025	- 0,025
10 798,7	60	- 0,005	0,035
10 800,5	60	0,025	0,005
10 806,1	60	0,025	0,065
10 814,4	60	0,055	- 0,025

10 816,3	60	0,025	0,005
10 819,1	60	0,025	- 0,025
10 827,4	60	- 0,005	0,035
10 829,3	60	0,025	0,005
10 834,8	60	0,025	0,065
10 843,2	60	0,055	- 0,025
10 845,0	60	0,025	0,005
10 847,8	60	0,025	- 0,025
10 856,2	60	- 0,005	0,035
10 858,0	60	0,025	0,005
10 863,6	60	0,025	0,065
10 871,9	60	0,055	- 0,025
10 873,8	60	0,025	0,005
10 876,6	60	0,025	- 0,025
10 884,9	60	- 0,005	0,035
10 886,8	60	0,025	0,005
10 889,6	60	0,025	0,035
10 897,9	60	0,055	- 0,025
10 899,8	60	0,025	0,005
10 902,6	60	0,025	- 0,025
10 908,1	60	- 0,005	0,035
10 910,0	60	0,025	0,005
10 912,8	60	0,025	0,035
10 921,1	60	0,055	- 0,025
10 923,0	60	0,025	0,005
10 925,8	60	0,025	- 0,025
10 931,3	60	- 0,005	0,035
10 933,2	60	0,025	0,005
10 936,0	60	0,025	0,035
10 944,3	60	0,055	- 0,025
10 946,2	60	0,025	0,005
10 949,0	60	0,025	- 0,025
10 954,5	60	- 0,005	0,035
10 956,4	60	0,025	0,005
10 959,2	60	0,025	0,035
10 967,5	60	0,055	- 0,025
10 969,4	60	0,025	0,005
10 972,1	60	0,025	- 0,025
10 977,7	60	- 0,005	0,035
10 979,6	60	0,025	0,005
10 982,4	60	0,025	0,035
10 990,7	60	0,055	- 0,025
10 992,6	60	0,025	0,005
10 995,3	60	0,025	- 0,025
11 000,9	60	- 0,005	0,035
11 002,8	60	0,025	0,005
11 005,5	60	0,025	0,035
11 013,9	60	0,055	- 0,025
11 015,8	60	0,025	0,005
11 018,5	60	0,025	- 0,025
11 024,1	60	- 0,005	0,035
11 026,0	60	0,025	0,005
11 028,7	60	0,025	0,035
11 037,1	60	0,055	- 0,025
11 038,9	60	0,025	0,005
11 041,7	60	0,025	- 0,025
11 047,3	60	- 0,005	0,035
11 049,2	60	0,025	0,005
11 051,9	60	0,025	0,035
11 057,5	60	0,055	0,005
11 059,4	60	0,025	0,005
11 062,1	60	0,025	- 0,025
11 067,7	60	- 0,005	0,035
11 069,6	60	0,025	0,005
11 072,3	60	0,025	0,035
11 077,9	60	0,055	0,005
11 079,8	60	0,025	0,005
11 082,6	60	0,025	- 0,025
11 088,1	60	- 0,005	0,035
11 090,0	60	0,025	0,005
11 092,8	60	0,025	0,035
11 098,3	60	0,055	0,005
11 100,2	60	0,025	0,005
11 103,0	60	0,025	- 0,025
11 108,5	60	- 0,005	0,035
11 110,4	60	0,025	0,005
11 113,2	60	0,025	0,035
11 118,7	60	0,055	0,005
11 120,6	60	0,025	0,005
11 123,4	60	0,025	- 0,025

11 128,9	60	- 0,005	0,035
11 130,8	60	0,025	0,005
11 133,6	60	0,025	0,035
11 139,1	60	0,055	0,005
11 141,0	60	0,025	0,005
11 143,8	60	0,025	- 0,025
11 149,4	60	- 0,005	0,035
11 151,2	60	0,025	0,005
11 154,0	60	0,025	0,035
11 159,6	60	0,055	0,005
11 161,4	60	0,025	0,005
11 164,2	60	0,025	- 0,025
11 169,8	60	- 0,005	0,035
11 171,6	60	0,025	0,005
11 174,4	60	0,025	0,035
11 180,0	60	0,055	0,005
11 181,8	60	0,025	0,005
11 184,6	60	0,025	- 0,025
11 187,4	60	- 0,005	0,005
11 189,2	60	0,025	0,005
11 192,0	60	0,025	0,035
11 197,6	60	0,055	0,005
11 199,5	60	0,025	0,005
11 202,2	60	0,025	- 0,025
11 205,0	60	- 0,005	0,005
11 206,9	60	0,025	0,005
11 209,7	60	0,025	0,035
11 215,2	60	0,055	0,005
11 217,1	60	0,025	0,005
11 219,9	60	0,025	- 0,025
11 222,6	60	- 0,005	0,005
11 224,5	60	0,025	0,005
11 227,3	60	0,025	0,035
11 232,9	60	0,055	0,005
11 234,7	60	0,025	0,005
11 237,5	60	0,025	- 0,025
11 240,3	60	- 0,005	0,005
11 242,1	60	0,025	0,005
11 244,9	60	0,025	0,035
11 250,5	60	0,055	0,005
11 252,3	60	0,025	0,005
11 255,1	60	0,025	- 0,025
11 257,9	60	- 0,005	0,005
11 259,8	60	0,025	0,005
11 262,5	60	0,025	0,035
11 268,1	60	0,055	0,005
11 270,0	60	0,025	0,005
11 272,7	60	0,025	- 0,025
11 275,5	60	- 0,005	0,005
11 277,4	60	0,025	0,005
11 280,2	60	0,025	0,035
11 285,7	60	0,055	0,005
11 287,6	60	0,025	0,005
11 290,4	60	0,025	- 0,025
11 293,2	60	- 0,005	0,005
11 295,0	60	0,025	0,005
11 297,8	60	0,025	0,035
11 303,4	60	0,055	0,005
11 305,2	60	0,025	0,005
11 308,0	60	0,025	- 0,025
11 310,8	60	- 0,005	0,005
11 312,6	60	0,025	0,005
11 315,4	60	0,025	0,035
11 321,0	60	0,055	0,005
11 322,8	60	0,025	0,005
11 325,6	60	0,025	- 0,025
11 328,4	60	- 0,005	0,005
11 330,3	60	0,025	0,005
11 333,1	60	0,025	0,035
11 338,6	60	0,055	0,005
11 340,5	60	0,025	0,005
11 343,3	60	0,025	- 0,025
11 346,0	60	- 0,005	0,005
11 347,9	60	0,025	0,005
11 350,7	60	0,025	0,035
11 356,2	60	0,055	0,005
11 358,1	60	0,025	0,005
11 360,9	60	0,025	- 0,025
11 363,7	60	- 0,005	0,005
11 365,5	60	0,025	0,005

11 368,3	60	0,025	0,035
11 371,1	60	0,055	0,005
11 372,9	60	0,025	0,005
11 375,7	60	0,025	- 0,025
11 378,5	60	- 0,005	0,005
11 380,4	60	0,025	0,005
11 383,2	60	0,025	0,035
11 385,9	60	0,055	0,005
11 387,8	60	0,025	0,005
11 390,6	60	0,025	- 0,025
11 393,4	60	- 0,005	0,005
11 395,2	60	0,025	0,005
11 398,0	60	0,025	0,035
11 400,8	60	0,055	0,005
11 402,6	60	0,025	0,005
11 405,4	60	0,025	- 0,025
11 408,2	60	- 0,005	0,005
11 410,1	60	0,025	0,005
11 412,8	60	0,025	0,035
11 415,6	60	0,055	0,005
11 417,5	60	0,025	0,005
11 420,3	60	0,025	- 0,025
11 423,0	60	- 0,005	0,005
11 424,9	60	0,025	0,005
11 427,7	60	0,025	0,035
11 430,5	60	0,055	0,005
11 432,3	60	0,025	0,005
11 435,1	60	0,025	- 0,025
11 437,9	60	- 0,005	0,005
11 439,7	60	0,025	0,005
11 442,5	60	0,025	0,035
11 445,3	60	0,055	0,005
11 447,2	60	0,025	0,005
11 450,0	60	0,025	- 0,025
11 452,7	60	- 0,005	0,005
11 454,6	60	0,025	0,005
11 457,4	60	0,025	0,035
11 460,2	60	0,055	0,005
11 462,0	60	0,025	0,005
11 464,8	60	0,025	- 0,025
11 467,6	60	- 0,005	0,005
11 469,4	60	0,025	0,005
11 472,2	60	0,025	0,035
11 475,0	60	0,055	0,005
11 476,9	60	0,025	0,005
11 479,6	60	0,025	- 0,025
11 482,4	60	- 0,005	0,005
11 484,3	60	0,025	0,005
11 487,1	60	0,025	0,035
11 489,8	60	0,055	0,005
11 491,7	60	0,025	0,005
11 494,5	60	0,025	- 0,025
11 497,3	60	- 0,005	0,005
11 499,1	60	0,025	0,005
11 501,9	60	0,025	0,035
11 504,7	60	0,055	0,005
11 506,6	60	0,025	0,005
11 509,3	60	0,025	- 0,025
11 512,1	60	- 0,005	0,005
11 514,0	60	0,025	0,005
11 516,8	60	0,025	0,035
11 519,5	60	0,055	0,005
11 521,4	60	0,025	0,005
11 524,2	60	0,025	- 0,025
11 527,0	60	- 0,005	0,005
11 528,8	60	0,025	0,005
11 531,6	60	0,025	0,035
11 534,4	60	0,055	0,005
11 536,2	60	0,025	0,005
11 539,0	60	0,025	- 0,025
11 541,8	60	- 0,005	0,005
11 543,7	60	0,025	0,005
11 546,4	60	0,025	0,035
11 549,2	60	0,055	0,005
11 551,1	60	0,025	0,005
11 553,9	60	0,025	- 0,025
11 556,7	60	- 0,005	0,005
11 558,5	60	0,025	0,005
11 561,3	60	0,025	0,035
11 564,1	60	0,055	0,005

11 565,9	60	0,025	0,005
11 568,7	60	0,025	- 0,025
11 571,5	60	- 0,005	0,005
11 573,4	60	0,025	0,005
11 576,1	60	0,025	0,035
11 578,9	60	0,055	0,005
11 580,8	60	0,025	0,005
11 583,6	60	0,025	- 0,025
11 586,3	60	- 0,005	0,005
11 588,2	60	0,025	0,005
11 591,0	60	0,025	0,035
11 593,8	60	0,055	0,005
11 595,6	60	0,025	0,005
11 598,4	60	0,025	- 0,025
11 601,2	60	- 0,005	0,005
11 603,0	60	0,025	0,005
11 605,8	60	0,025	0,035
11 608,6	60	0,055	0,005
11 610,5	60	0,025	0,005
11 613,2	60	0,025	- 0,025
11 616,0	60	- 0,005	0,005
11 617,9	60	0,025	0,005
11 620,7	60	0,025	0,035
11 623,5	60	0,055	0,005
11 625,3	60	0,025	0,005
11 628,1	60	0,025	- 0,025
11 630,9	60	- 0,005	0,005
11 632,7	60	0,025	0,005
11 635,5	60	0,025	0,035
11 638,3	60	0,055	0,005
11 640,2	60	0,025	0,005
11 642,9	60	0,025	- 0,025
11 645,7	60	- 0,005	0,005
11 647,6	60	0,025	0,005
11 650,4	60	0,025	0,035
11 653,1	60	0,055	0,005
11 655,0	60	0,025	0,005
11 657,8	60	0,025	- 0,025
11 660,6	60	- 0,005	0,005
11 662,4	60	0,025	0,005
11 665,2	60	0,025	0,035
11 668,0	60	0,055	0,005
11 669,8	60	0,025	0,005
11 672,6	60	0,025	- 0,025
11 675,4	60	- 0,005	0,005
11 677,3	60	0,025	0,005
11 680,0	60	0,025	0,035
11 682,8	60	0,055	0,005
11 684,7	60	0,025	0,005
11 687,5	60	0,025	- 0,025
11 690,3	60	- 0,005	0,005
11 692,1	60	0,025	0,005
11 694,9	60	0,025	0,035
11 697,7	60	0,055	0,005
11 699,5	60	0,025	0,005
11 702,3	60	0,025	- 0,025
11 705,1	60	- 0,005	0,005
11 707,0	60	0,025	0,005
11 709,7	60	0,025	0,035
11 712,5	60	0,055	0,005
11 714,4	60	0,025	0,005
11 717,2	60	0,025	- 0,025
11 719,9	60	- 0,005	0,005
11 721,8	60	0,025	0,005
11 724,6	60	0,025	0,035
11 727,4	60	0,055	0,005
11 729,2	60	0,025	0,005
11 732,0	60	0,025	- 0,025
11 734,8	60	- 0,005	0,005
11 736,6	60	0,025	0,005
11 739,4	60	0,025	0,035
11 742,2	60	0,055	0,005
11 744,1	60	0,025	0,005
11 746,8	60	0,025	- 0,025
11 749,6	60	- 0,005	0,005
11 751,5	60	0,025	0,005
11 754,3	60	0,025	0,035
11 757,1	60	0,055	0,005
11 758,9	60	0,025	0,005
11 761,7	60	0,025	- 0,025

11 764,5	60	- 0,005	0,005
11 766,3	60	0,025	0,005
11 769,1	60	0,025	0,035
11 771,9	60	0,055	0,005
11 773,8	60	0,025	0,005
11 776,5	60	0,025	- 0,025
11 779,3	60	- 0,005	0,005
11 781,2	60	0,025	0,005
11 784,0	60	0,025	0,035
11 786,7	60	0,055	0,005
11 788,6	60	0,025	0,005
11 791,4	60	0,025	- 0,025
11 794,2	60	- 0,005	0,005
11 796,0	60	0,025	0,005
11 798,8	60	0,025	0,035
11 801,6	60	0,055	0,005
11 803,4	60	0,025	0,005
11 806,2	60	0,025	- 0,025
11 809,0	60	- 0,005	0,005
11 810,9	60	0,025	0,005
11 813,6	60	0,025	0,035
11 816,4	60	0,055	0,005
11 818,3	60	0,025	0,005
11 821,1	60	0,025	- 0,025
11 823,9	60	- 0,005	0,005
11 825,7	60	0,025	0,005
11 828,5	60	0,025	0,035
11 831,3	60	0,055	0,005
11 833,1	60	0,025	0,005
11 835,9	60	0,025	- 0,025
11 838,7	60	- 0,005	0,005
11 840,6	60	0,025	0,005
11 843,3	60	0,025	0,035
11 846,1	60	0,055	0,005
11 848,0	60	0,025	0,005
11 850,8	60	0,025	- 0,025
11 853,5	60	- 0,005	0,005
11 855,4	60	0,025	0,005
11 858,2	60	0,025	0,035
11 861,0	60	0,055	0,005
11 862,8	60	0,025	0,005
11 865,6	60	0,025	- 0,025
11 868,4	60	- 0,005	0,005
11 870,2	60	0,025	0,005
11 873,0	60	0,025	0,035
11 875,8	60	0,055	0,005
11 877,7	60	0,025	0,005
11 883,2	60	0,025	0,005
11 886,0	60	- 0,005	0,005
11 887,9	60	0,025	0,005
11 890,7	60	0,025	0,035
11 893,4	60	0,055	0,005
11 895,3	60	0,025	0,005
11 900,9	60	0,025	0,005
11 903,6	60	- 0,005	0,005
11 905,5	60	0,025	0,005
11 908,3	60	0,025	0,035
11 911,1	60	0,055	0,005
11 912,9	60	0,025	0,005
11 918,5	60	0,025	0,005
11 921,3	60	- 0,005	0,005
11 923,1	60	0,025	0,005
11 925,9	60	0,025	0,035
11 928,7	60	0,055	0,005
11 930,5	60	0,025	0,005
11 936,1	60	0,025	0,005
11 938,9	60	- 0,005	0,005
11 940,8	60	0,025	0,005
11 943,5	60	0,025	0,035
11 946,3	60	0,055	0,005
11 948,2	60	0,025	0,005
11 953,7	60	0,025	0,005
11 956,5	60	- 0,005	0,005
11 958,4	60	0,025	0,005
11 961,2	60	0,025	0,035
11 963,9	60	0,055	0,005
11 965,8	60	0,025	0,005
11 971,4	60	0,025	0,005
11 974,2	60	- 0,005	0,005
11 976,0	60	0,025	0,005

11 978,8	60	0,025	0,035
11 981,6	60	0,055	0,005
11 983,4	60	0,025	0,005
11 989,0	60	0,025	0,005
11 991,8	60	- 0,005	0,005
11 993,6	60	0,025	0,005
11 996,4	60	0,025	0,035
11 999,2	60	0,055	0,005
12 001,1	60	0,025	0,005
12 006,6	60	0,025	0,005
12 009,4	60	- 0,005	0,005
12 011,3	60	0,025	0,005
12 014,0	60	0,025	0,035
12 016,8	60	0,055	0,005
12 018,7	60	0,025	0,005
12 024,3	60	0,025	0,005
12 027,0	60	- 0,005	0,005
12 028,9	60	0,025	0,005
12 031,7	60	0,025	0,035
12 034,5	60	0,055	0,005
12 036,3	60	0,025	0,005
12 041,9	60	0,025	0,005
12 044,7	60	- 0,005	0,005
12 046,5	60	0,025	0,005
12 049,3	60	0,025	0,035
12 052,1	60	0,055	0,005
12 053,9	60	0,025	0,005
12 059,5	60	0,025	0,005
12 062,3	60	- 0,005	0,005
12 064,1	60	0,025	0,005
12 066,9	60	0,025	0,035
12 069,7	60	0,055	0,005
12 071,6	60	0,025	0,005
12 077,1	60	0,025	0,005
12 079,9	60	- 0,005	0,005
12 081,8	60	0,025	0,005
12 084,6	60	0,025	0,035
12 087,3	60	0,055	0,005
12 089,2	60	0,025	0,005
12 094,8	60	0,025	0,005
12 097,5	60	- 0,005	0,005
12 099,4	60	0,025	0,005
12 102,2	60	0,025	0,035
12 105,0	60	0,055	0,005
12 106,8	60	0,025	0,005
12 112,4	60	0,025	0,005
12 115,2	60	- 0,005	0,005
12 117,0	60	0,025	0,005
12 119,8	60	0,025	0,035
12 122,6	60	0,055	0,005
12 124,5	60	0,025	0,005
12 130,0	60	0,025	0,005
12 132,8	60	- 0,005	0,005
12 134,7	60	0,025	0,005
12 137,4	60	0,025	0,035
12 140,2	60	0,055	0,005
12 142,1	60	0,025	0,005
12 147,6	60	0,025	0,005
12 150,4	60	- 0,005	0,005
12 152,3	60	0,025	0,005
12 155,1	60	0,025	0,035
12 157,9	60	0,055	0,005
12 159,7	60	0,025	0,005
12 165,3	60	0,025	0,005
12 168,1	60	- 0,005	0,005
12 169,9	60	0,025	0,005
12 172,7	60	0,025	0,035
12 175,5	60	0,055	0,005
12 177,3	60	0,025	0,005
12 182,9	60	0,025	0,005
12 185,7	60	- 0,005	0,005
12 187,5	60	0,025	0,005
12 190,3	60	0,025	0,035
12 193,1	60	0,055	0,005
12 195,0	60	0,025	0,005
12 200,5	60	0,025	0,005
12 203,3	60	- 0,005	0,005
12 205,2	60	0,025	0,005
12 208,0	60	0,025	0,035
12 210,7	60	0,055	0,005

12 212,6	60	0,025	0,005
12 218,2	60	0,025	0,005
12 220,9	60	- 0,005	0,005
12 222,8	60	0,025	0,005
12 225,6	60	0,025	0,035
12 228,4	60	0,055	0,005
12 230,2	60	0,025	0,005
12 235,8	60	0,025	0,005
12 238,6	60	- 0,005	0,005
12 240,4	60	0,025	0,005
12 243,2	60	0,025	0,035
12 246,0	60	0,055	0,005
12 247,8	60	0,025	0,005
12 253,4	60	0,025	0,005
12 256,2	60	- 0,005	0,005
12 258,1	60	0,025	0,005
12 260,8	60	0,025	0,035
12 263,6	60	0,055	0,005
12 265,5	60	0,025	0,005
12 271,0	60	0,025	0,005
12 273,8	60	- 0,005	0,005
12 275,7	60	0,025	0,005
12 278,5	60	0,025	0,035
12 281,2	60	0,055	0,005
12 283,1	60	0,025	0,005
12 288,7	60	0,025	0,005
12 291,5	60	- 0,005	0,005
12 293,3	60	0,025	0,005
12 296,1	60	0,025	0,035
12 298,9	60	0,055	0,005
12 300,7	60	0,025	0,005
12 306,3	60	0,025	0,005
12 309,1	60	- 0,005	0,005
12 310,9	60	0,025	0,005
12 313,7	60	0,025	0,035
12 316,5	60	0,055	0,005
12 318,4	60	0,025	0,005
12 323,9	60	0,025	0,005
12 326,7	60	- 0,005	0,005
12 328,6	60	0,025	0,005
12 331,3	60	0,025	0,035
12 334,1	60	0,055	0,005
12 336,0	60	0,025	0,005
12 341,6	60	0,025	0,005
12 344,3	60	- 0,005	0,005
12 346,2	60	0,025	0,005
12 349,0	60	0,025	0,035
12 351,8	60	0,055	0,005
12 353,6	60	0,025	0,005
12 359,2	60	0,025	0,005
12 362,0	60	- 0,005	0,005
12 363,8	60	0,025	0,005
12 366,6	60	0,025	0,035
12 369,4	60	0,055	0,005
12 371,2	60	0,025	0,005
12 376,8	60	0,025	0,005
12 379,6	60	- 0,005	0,005
12 381,4	60	0,025	0,005
12 384,2	60	0,025	0,035
12 387,0	60	0,055	0,005
12 388,9	60	0,025	0,005
12 394,4	60	0,025	0,005
12 397,2	60	- 0,005	0,005
12 399,1	60	0,025	0,005
12 401,9	60	0,025	0,035
12 404,6	60	0,055	0,005
12 406,5	60	0,025	0,005
12 412,1	60	0,025	0,005
12 414,8	60	- 0,005	0,005
12 416,7	60	0,025	0,005
12 419,5	60	0,025	0,035
12 422,3	60	0,055	0,005
12 424,1	60	0,025	0,005
12 429,7	60	0,025	0,005
12 432,5	60	- 0,005	0,005
12 434,3	60	0,025	0,005
12 437,1	60	0,025	0,035
12 439,9	60	0,055	0,005
12 441,8	60	0,025	0,005
12 447,3	60	0,025	0,005

12 450,1	60	- 0,005	0,005
12 452,0	60	0,025	0,005
12 454,7	60	0,025	0,035
12 457,5	60	0,055	0,005
12 459,4	60	0,025	0,005
12 464,9	60	0,025	0,005
12 467,7	60	- 0,005	0,005
12 469,6	60	0,025	0,005
12 475,2	60	0,025	0,005
12 477,9	60	0,055	0,005
12 479,8	60	0,025	0,005
12 485,4	60	0,025	0,005
12 488,1	60	- 0,005	0,005
12 490,0	60	0,025	0,005

Annex 10 – Appendix 4

Test method (b) - Test equipment tolerances

Table B.1

Instrumentation accuracy

Parameter	*Control accuracy*	*Instrumentation accuracy at full scale*
Tyre forces	Fz: ± 50 N or 1 % using filtered values whichever is greater. Fy: ± 100 N or 5 % using filtered values whichever is greater, for the difference between input peaks and actually generated peaks. Fx: ± 100 N or 5 % using filtered values whichever is greater, for the difference between input peaks and actually generated peaks. My: ± 40 Nm or 5 % using filtered values whichever is greater, for the difference between input peaks and actually generated peaks.	Fz: ± 1 % Fy: ± 1 % Fx: ± 1 % My: ± 1 %
Inflation pressure	± 3 kPa	± 3 kPa
Mass scale	not applicable	± 2 g
Test duration	For the test time durations, the total time of an actual test shall not differ more than ± 5 % from the total input time, 68,83h (247 800s). The interval of measurement shall be more than 1Hz.	± 0,02 s for the time increments
Camber angle	0 +/- 0,1 degrees	0 +/-0,1 degrees
Thermometer	± 5 °C	± 0,5 °C
Speed	± 2 km/h	± 0,1%

Annex 10 – Appendix 5

Test method (b) - Replacement of sandpaper surface

Sandpaper surface shall be replaced when it does not meet the specifications described in 2.4.2.3.;

The sandpaper surface should be replaced either when:

The running distance reaches 20 000 km for 2 positions drum in case of 3 m drum diameter, or 40 000 km for 1 position drum in case of 3 m drum diameter,

In case of drum diameter is not 3 m, the following formula applies:

Road surface replacement distance (km) = Road surface replacement distance (standard value) x Diameter of drum owned by each testing institution (m) / Standard drum diameter (m)

Where:

Road surface replacement distance (standard value) = 20 000 km;

Standard drum diameter = 3 m.

Annex 10 – Appendix 6

Test method (b) - Example of a test report for indoor drum test method

The test report shall include the following information.

Test report number:			Test date:	~	
Test machine identification:					
Drum circumference (m),				Beginning of test	End of test
Test cycle (2 positions /1 position)			MPD of test surface (mm):		
	Talc or Silica		Micro roughness of test surface (mm)		

Type of test tyre		Reference tyre	Candidate tyre
Tyre class			
Brand			
Pattern/trade description		SRTT…	
Tyre size designation			
Service description			
Test load (N)			
Test inflation pressure (kPa)			
Tyre identification			
3PMSF marking (Y/N)			
Rim width			
Inflation pressure (kPa)	Beginning of test		
	End of test		
Mass of tyre (g)	Before test		
	After test		
Test distance (km)			
Abrasion rate (mg/km)			
Abrasion level (mg/km/t)			
Abrasion index			
Average ambient temp. (°C)			

Type of test tyre	Reference tyre	Candidate tyre
RMS of G(x)		
RMS of G(y)		
RMS of G(x,y)		
Average of Fz		
Amount of powder sprayed relative to reference tyre		
Remarks		