

27 February 2025

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## Agreement

### **Concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations\***

(Revision 3, including the amendments which entered into force on 14 September 2017)

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### **Addendum 116 – UN Regulation No. 117**

### **Revision 6 - Amendment 2**

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

### **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**

This document is meant purely as documentation tool. The authentic and legal binding text is: ECE/TRANS/WP.29/2024/65 as amended by para 90, ECE/TRANS/WP.29/1179.



**UNITED NATIONS**

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\* Former titles of the Agreement:

Agreement concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, done at Geneva on 20 March 1958 (original version);  
Agreement concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions, done at Geneva on 5 October 1995 (Revision 2).



*Table of contents*, amend to read:

"[...]

6. Requirements

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

"[...]"

*Annexes*, amend to read:

"[...]

4 Reserved

"[...]

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.....

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*Paragraph 1., footnote 1*, amend to read:

"<sup>1</sup> As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3)–"

*Paragraph 1.1.*, amend to read:

"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:"

*Insert a new paragraph 1.3.*, to read:

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

*Paragraph 2., footnotes 2 to 4*, amend to read:

"<sup>2</sup> Class C1 tyres correspond to "passenger car tyres" in ISO 4000-1:2021.

<sup>3</sup> 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.

<sup>4</sup> The rolling resistance is expressed in newtons and the load is expressed in kilo-newton. The rolling resistance coefficient is dimensionless."

*Paragraph 2.7.*, amend to read:

"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."

*Paragraph 2.11.*, amend to read:

- "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.<sup>2</sup>"

*Paragraph 2.13.*, amend to read:

- "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."

*Paragraph 2.18.*, amend to read:

- "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".

*Insert a new paragraph 2.21. and its subparagraphs*, to read:

- "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.
- 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)."

*Insert a new paragraph 3.1.1.1.*, to read:

- "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;"

*Paragraph 3.2.1.*, amend to read:

- "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."

*Paragraph 5.2.2., amend to read:*

"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."

*Insert new paragraph 5.7 to 5.10., to read:*

"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."

*Paragraph 6, title, amend to read:*

## **"6. Requirements"**

*Paragraph 6.5.1., amend to read:*

"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:

<i>Class of tyre</i>	<i>Snow grip index (brake on snow method) <sup>(a)</sup></i>		<i>Snow grip index (spin traction method) <sup>(b)</sup></i>	<i>Snow grip index (acceleration method) <sup>(c)</sup></i>
	<i>Ref.s = SRTT14, SRTT16</i>	<i>Ref. = SRTT16C</i>	<i>Ref. = SRTT14, SRTT16</i>	<i>Ref.s = SRTT19.5, SRTT22.5, SRTT19.5 siped, SRTT22.5 siped</i>
C1	1.07	No	1.10	No
C2	No	1.02	1.10	No
C3	No	No	No	1.25

<sup>(a)</sup> See paragraph 3. of Annex 7 to this Regulation

<sup>(b)</sup> See paragraph 2. of Annex 7 to this Regulation

<sup>(c)</sup> See paragraph 4. of Annex 7 to this Regulation "

*Paragraph 8.3.2., amend to read:*

"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."

*Add a new paragraph 8.3.2.1, to read:*

"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."

*Insert a new paragraph 8.3.4. to read:*

"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."

*Add new paragraphs 12.18. to 12.26., to read:*

"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:

<i>Tyre class</i>	<i>Reference tyres</i>
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:

<i>Tyre class</i>	<i>Reference tyres</i>
C2	SRTT16C
C3	SRTT19.5 siped or SRTT22.5 siped

"

*Annex 1,*

*Item 8.1., amend to read:*

- "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 <sup>2</sup>"

*Insert a new item 8.6., to read:*

- "8.6. Abrasion level available in the case of class C1 tyres (Yes/No)<sup>2</sup>"

Insert a new item 8.6.1., to read:

"8.6.1. Use of the vehicle on public open roads method<sup>2</sup> or the indoor drum method<sup>2</sup>"

Annex 3,

Paragraph 2.1., amend to read:

"2.1. Test site

[...]

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.

[...]"

Paragraph 4.2. and its subparagraphs, amend to read:

"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  $\vartheta_i$  (where  $i$  denotes the number of the single measurement) shall be normalized to a test surface reference temperature  $\vartheta_{\text{ref}}$  by applying a temperature correction, according to the following formula:

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

where:

$$\vartheta_{\text{ref}} = 20 \text{ }^{\circ}\text{C},$$

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

- 0.03 dB(A)/ $^{\circ}\text{C}$  when  $\vartheta_i > \vartheta_{\text{ref}}$  and
- 0.06 dB(A)/ $^{\circ}\text{C}$  when  $\vartheta_i < \vartheta_{\text{ref}}$ .

For class C2 tyres, the coefficient  $K$  is  $-0.02 \text{ dB(A)/}^{\circ}\text{C}$ .

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  $\vartheta_i$  (where  $i$  denotes the number of the single measurement) shall be normalized to a test surface reference temperature  $\vartheta_{\text{ref}}$  by applying a temperature correction, according to the following formula:

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

where:

$$\vartheta_{\text{ref}} = 20 \text{ }^{\circ}\text{C},$$

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

Class C1 tyres		
	( $^{\circ}\text{C}$ )	( $^{\circ}\text{C}$ )
Tyres that are classified as tyre for use in severe snow conditions		
Other tyres		

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<i>Class C2 tyres</i>		
	(°C)	(°C)
Tyres that are classified as tyre for use in severe snow conditions		
Other tyres		

- 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."

*Annex 4*, amend to read:

## " Annex 4

### Reserved"

*Annex 5, Part (B), paragraph 1.1. and its subparagraphs*, amend to read:

- "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  $(0.7 \pm 0.3)$  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).

<i>Tyre class</i>	<i>SRTT</i>	<i>Trailer method <math>\mu_{\text{peak}}</math> range</i>	<i>Vehicle method BFC range</i>
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  $CV_\mu$  exceeds 4 per cent, dismiss the results and repeat the braking test.

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

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

where

$\vartheta$  is the wetted track surface temperature in degrees Celsius,

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

The temperature corrected average peak braking force coefficient ( $\mu_{\text{peak,corr}}$ ) 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  $CV_\mu$  exceeds 5 per cent, dismiss the results and repeat the braking test.

No temperature correction is applied.

The average peak braking force coefficient ( $\overline{\mu_{\text{peak}}}$ ) 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."

Paragraph 1.4., amend to read:

- "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

"

Paragraph 2.1.2.13, amend to read:

- "2.1.2.13. Validation of results

For the reference tyre:

- If the coefficient of variation of the peak braking coefficient  $CV_{\mu}$  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.
- 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:

[...]"

Paragraph 2.1.2.14., amend to read:

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

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

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)."

Paragraph 2.2.4., amend to read:

"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"

Paragraph 2.2.2.7.2., amend to read:

"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."

Paragraph 2.2.2.7.5., amend to read:

"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	$G = f \cdot \frac{BFC(T)}{BFC(R)}$
Configuration C2: candidate tyres on front axle and reference tyres on rear axle	$G = f \cdot \frac{BFC(T) \cdot [a + b + h \cdot BFC(R)] - a \cdot BFC(R)}{BFC(R) \cdot [b + h \cdot BFC(T)]}$

Configuration C3: reference tyres on front axle and candidate tyres on rear axle	$G = f \cdot \frac{BFC(T) \cdot [-a - b + h \cdot BFC(R)] + b \cdot BFC(R)}{BFC(R) \cdot [-a + h \cdot BFC(T)]}$
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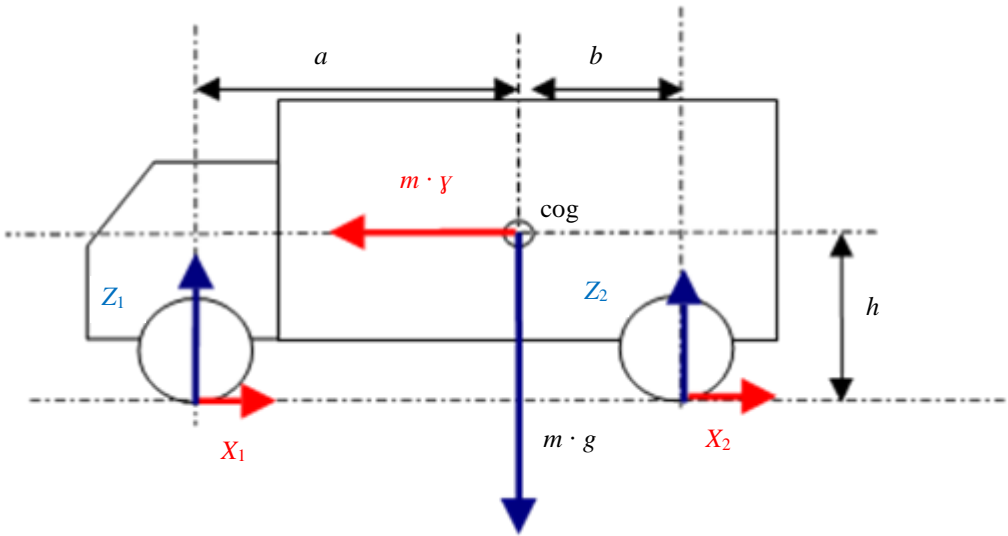
where

<i>For class C2 tyres</i>	
<i>SRTT16C</i>	
<i>f = 1</i>	
<i>For class C3 tyres</i>	
<i>SRTT19.5, SRTT22.5</i>	<i>SRTT19.5 siped, SRTT22.5 siped</i>
<i>f = 1</i>	<i>f = 1.02</i>

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
- γ*: loaded vehicle acceleration [m·s<sup>-2</sup>]
- g*: acceleration due to the gravity [m·s<sup>-2</sup>]
- X*<sub>1</sub>: longitudinal (X-direction) reaction of the front tyre on the road
- X*<sub>2</sub>: longitudinal (X-direction) reaction of the rear tyre on the road
- Z*<sub>1</sub>: normal (Z-direction) reaction of the front tyre on the road
- Z*<sub>2</sub>: normal (Z-direction) reaction of the rear tyre on the road

Figure 1  
Nomenclature explanation related to grip index of the tyre



Paragraph 2.2.2.8.4., amend to read:

"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)"

Annex 5, Appendix, amend to read:

## "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):		
$\mu_{\text{peak,corr}}^{(4)}$ :	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 <sup>(1)</sup> (kPa)						
Tyre identification						
M+S marking (Y/N)						
3PMSF marking (Y/N)						
Rim						
Load (kg)						
Pressure (kPa)						
$\mu_{peak}$	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
$\overline{\mu_{peak}}$						
Standard deviation, $\sigma_{\mu}$						
$CV_{\mu} \leq 4 \%$ <sup>(2)</sup>						
$CV_{val}(\mu_{peak}) \leq 5 \%$ <sup>(3)</sup>						
$\mu_{peak,corr}(R)$						
$\mu_{peak,adj}(R)$						
$f$						
Wet grip index						
Wetted surface temp. (°C)						
Ambient temp. (°C)						
Remarks						

as required by paragraph 4.1. of this Regulation

<sup>(2)</sup> For classes C2 and C3 tyres, the limit is 5 %.

<sup>(3)</sup> For classes C2 and C3 tyres,  $CVal(\mu_{peak})$  is not defined nor applied.

<sup>(4)</sup> 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:
Texture depth (mm):		Wetted surface temp. (°C):		
$BFC_{ave,corr,1}^{(5)}$ ; or $BFC_{ave}$ or $\mu_{peak,corr}^{(4)}$ :		Ambient temp (°C):		
$BFC_{ave,corr,2}^{(5)}$ :				
$CVal(BFC_{ave,corr})$ :				
Water depth (mm):				

Vehicle	
Brand:	
Model:	
Type:	
Year of registration:	
Maximum axle load:	<div style="display: flex; justify-content: space-between; width: 100%;"> <span>Front</span> <span>Rear</span> </div>

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 <sup>(1)</sup> (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:					
	<i>Braking distance (m)</i>	<i>BFC<sub>i</sub></i>	<i>Braking distance (m)</i>	<i>BFC<sub>i</sub></i>	<i>Braking distance (m)</i>	<i>BFC<sub>i</sub></i>	<i>Braking distance (m)</i>	<i>BFC<sub>i</sub></i>	<i>Braking distance (m)</i>	<i>BFC<sub>i</sub></i>
Measurement	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
$\overline{BFC_{ave}}$										
Standard deviation, $\sigma_{BFC}$										
$CV_{BFC} \leq 4\%$ <sup>(2)</sup>										
$CVal(BFC_{ave}) \leq 5\%$ <sup>(3)</sup>										
$BFC_{ave,corr}(R)$										
$BFC_{adj}(R)$										
$f$										
Wet grip index										
Wetted surface temp. (°C)										
Ambient temp. (°C)										
Remarks										

<sup>(1)</sup> 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.

<sup>(2)</sup> For classes C2 and C3 tyres, the limit is 3 %.

<sup>(3)</sup> For classes C2 and C3 tyres,  $CVal(BFC_{ave})$  is not defined nor applied.

<sup>(4)</sup> For classes C2 and C3 tyres, depending on whether paragraph 1.1.1.1 or 1.1.1.2. applies.

<sup>(5)</sup> For classes C2 and C3 tyres,  $BFC_{ave,corr}$  is not defined nor applied."

Annex 6,

Paragraph 2.2., amend to read:

"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."

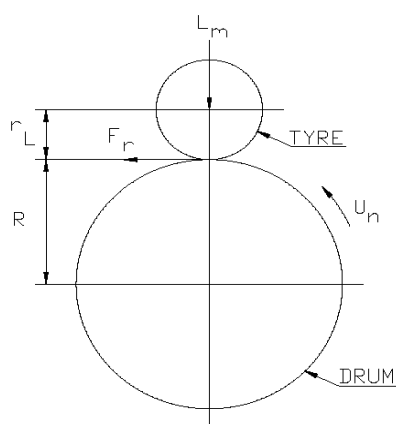
Paragraph 4.5., amend to read:

"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."



*Paragraphs 5.1.1. and 5.1.2., amend to read:*

"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.

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."

*Paragraph 5.2.1., amend to read:*

"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."

*Paragraph 6.1., amend to read:*

"6.1. Rolling resistance coefficient

The rolling resistance coefficient  $C_r$  is calculated by dividing the rolling resistance by the load on the tyre:

$$C_r = \frac{F_r}{L_m}$$

Where:

$F_r$  is the rolling resistance, in newtons,

$L_m$  is the test load, in kN."

*Annex 6, Appendix 1, paragraph 2.1., amend to read:*

"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."

*Annex 7,*

*Paragraph 2., amend to read:*

"2. Spin traction method for classes C1 and C2 tyres (traction force test per paragraph 6.5. (b) of this Regulation)."

Paragraph 4.5.1., amend to read:

- "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."

Paragraph 4.8.4., amend to read;

- "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.

$$SG(Tn) = f \cdot \frac{\overline{AA_{Tn}}}{wa_{SRTT}}$$

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	$f = 1.680$

"

Paragraph 4.9.2., amend to read:

- "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.

$$SG1 = f \cdot \frac{\overline{AA_C}}{wa_{SRTT}}$$

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  $\pm 5$  °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:

$$SG = SG1 \cdot SG2$$

"

Annex 7, Appendix 3, Part 5, amend to read:

"5. Test results: average accelerations ( $\text{m} \cdot \text{s}^{-2}$ )

Run number	Specification	SRTT <sup>(1st test)</sup>	Candidate 1	Candidate 2	Candidate 3	SRTT <sup>(2nd test)</sup>
1						
2						
3						
4						
5						
6						
Mean						
Standard deviation						
Slip ratio (per cent)						
Coefficient of variation	$CV_{AA} \leq 6 \%$					
Coefficient of Validation	$CVal_{AA}(SRTT) \leq 6 \%$					
SRTT weighted average						
$f$						
Snow grip index		1.00				

<sup>(1)</sup> corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation

<sup>(2)</sup> refer to single load"

Annex 8,

Paragraph 2.1.3.1., amend to read:

"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."

Paragraph 2.1.3.2.1., amend to read:

"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."

Paragraph 2.4.5.1.2., amend to read:

"2.4.5.1.2. The control tyre shall pass the ice grip index threshold defined in paragraph 6.5.2. of this Regulation."

Annex 9,

Paragraph 2.1.8., amend to read:

"2.1.8. "Central zone" means the area on the tread width defined by the  $\frac{3}{4}$  (75%) of the reference tread width (C) symmetrically measured from the centre line (see Figure 4)."

Paragraph 2.1.10., amend to read:

"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)."

Paragraph 2.2.1.2.1., amend to read:

"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)

[...]"

Annex 9, Appendix 1, amend to read:

"[...]

Roughness measurement

Arithmetical mean height of the absolute values of the roughness profile ( $\mu\text{m}$ )		Sections			
		1	2	3	4
Trans. Loc.	1 (right)				
	2 (centre)				
	3 (left)				
Average					

"

Insert a new Annex 10, to read:

## "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 followings 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  $\leq 13$ .
- 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  $f_2$  coefficient" (measured in  $\text{N}/(\text{km}/\text{h})^2$ ) 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  $\text{m}/\text{s}^2$ ) 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  $\text{m}/\text{s}^2$ ) 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
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
$ALC$	$\text{mg}/\text{km}/\text{t}$	Abrasion level of candidate tyre at test conditions
$ALRT$	$\text{mg}/\text{km}/\text{t}$	Abrasion level of reference tyre at test conditions
$ARC$	$\text{mg}/\text{km}$	Abrasion rate of candidate tyre at test conditions
$ARR$	$\text{mg}/\text{km}$	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 $i$
$O_S$	$\text{mg}/\text{km}/\text{t}$	Offset of the regression lines of the reference tyre abrasion level of SRTT17S
$O_W$	$\text{mg}/\text{km}/\text{t}$	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 <i>SRTT17S</i> to temperature variation
$S_w$	mg/km/t/°C	Sensitivity of <i>SRTT17W</i> to temperature variation
$T_i$	°C	Average temperature of the test
$\bar{T}$	°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  $\pm 2$  g.

1.4.2. Instruments for alignment and camber measurement on vehicle

The device shall have an accuracy of  $\pm 0.033$  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  $\pm 0.1$  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 of this Regulation.

The distance ran by the tyre shall equal the GNSS reported distance plus the distance ran without a GNSS signal, unless the latter is estimated by the GNSS system., 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  $\pm 3$  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  $\pm 1$  °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  $\pm 2$  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. Vehicle alignment measurement procedure

The vehicle 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  $\pm 0.15$  degrees for toe and  $\pm 0.3$  degrees for camber from initial measurement under the same condition.
  - 1.6.2. Vehicles acceptable suspension and static tuning 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  $0 \pm 0.1$  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  $0 \pm 0.05$  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. Vehicles acceptable suspension and static tuning 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  $0 \pm 0.1$  degrees;
  - (b) Camber angle on the front axle set to  $0 \pm 0.1$  degrees;
  - (c) Toe IN/OUT angle per wheel on the rear axle set to  $0 \pm 0.1$  degrees;
  - (d) Camber angle on the rear axle set to  $0 \pm 0.1$  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  $0 \pm 0.05$  degrees;
  - (b) Camber angle on the front axle set to  $0 \pm 0.1$  degrees;
  - (c) Toe IN/OUT angle per wheel on the rear axle set to  $0 \pm 0.1$  degrees;
  - (d) Camber angle on the rear axle set to  $0 \pm 0.1$  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. Vehicle acceptable suspension and static tuning 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 respecting 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 ( $0^\circ \pm$  tolerance);
  - (ii) Front camber angle shall not differ by more than  $0.5^\circ$  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  $0.6^\circ$  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  $0.1^\circ$  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  $0 \pm 0.1$  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  $\pm 0.05$  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  $f_2$  value of the vehicle with reference tyres shall be lower than or equal to 1.2 times the  $f_2$  value of the vehicles with candidate tyres.

The provision defined in this paragraph does not apply when the  $f_2$  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 index)

The total vehicle mass shall allow to load the tyre with a total load of  $(67 \pm 7)$  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:  $670 \times 4 = 2680$  kg.

The loaded vehicle mass shall then be  $2680 \times 67 \% = 1796$  kg with a tolerance of  $2680 \times 7 \%$ , which corresponds to  $\pm 188$  kg.

Load distribution between front and rear axle shall be as following:

(a) For FWD vehicles

Front axle load:  $(56 \pm 7)$  per cent of total vehicle load.

Rear axle load:  $(44 \pm 7)$  per cent of total vehicle load.

(b) For AWD/RWD vehicles

Front axle load:  $(50 \pm 7)$  per cent of total vehicle load.

Rear axle load:  $(50 \pm 7)$  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<sup>2</sup>;
  - (iii) The lateral acceleration standard deviation shall be in range from 0.15 to 1.00 m/s<sup>2</sup>.
- (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<sup>2</sup>;
  - (iii) The lateral acceleration standard deviation shall be in range from 0.40 to 1.20 m/s<sup>2</sup>.
- (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 deceleration standard deviation and maximum values shall apply:

1.6.13.3.1. Standard deviation

- (a) Longitudinal acceleration: 0.45 m/s<sup>2</sup> ± 10 per cent;
- (b) Lateral acceleration: 0.93 m/s<sup>2</sup> ± 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:  $\pm 5 \text{ m/s}^2$  for a distance representing at least 99.98 per cent of the total distance;
- (b) Lateral acceleration:  $\pm 5 \text{ m/s}^2$  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 8000 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.

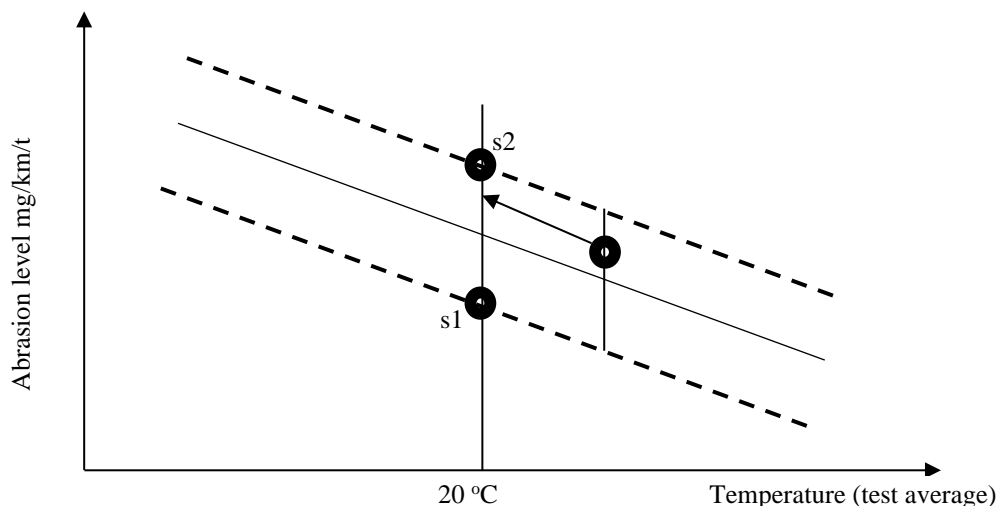


Figure 1: The normalised to 20°C abrasion level of the test shall be within s1 and s2.

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:

$$S_S = \frac{\sum_{i=1}^n (ALRT_i - \overline{ALRT}) \times (T_i - \bar{T})}{\sum_{i=1}^n (T_i - \bar{T})^2} \quad \text{for SRTT17S}$$

$$S_W = \frac{\sum_{i=1}^n (ALRT_i - \overline{ALRT}) \times (T_i - \bar{T})}{\sum_{i=1}^n (T_i - \bar{T})^2} \quad \text{for SRTT17W}$$

The offsets of the regression lines of the reference tyre abrasion ~~rate~~ level to the average test temperature during the test are calculated by means of the following equations:

$$O_S = \overline{ALRT} - S_S \cdot \bar{T} \quad \text{for SRTT17S}$$

$$O_W = \overline{ALRT} - S_W \cdot \bar{T} \quad \text{for SRTT17W}$$

The circuit abrasion levels at the relevant temperatures are calculated by means of the following equations:

$$R_{ACS} = O_S + S_S \cdot 20 \quad \text{for SRTT17S}$$

$$R_{ACW} = O_W + S_W \cdot 10 \quad \text{for SRTT17W}$$

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;
- $\bar{T}$  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 ~~or~~ 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 8000 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  $8000 \pm 300$  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) Vehicle 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) Vehicle alignment, in loaded condition, accompanied by correction to initial value if relevant for vehicle used for reference tyres. The vehicle 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) Vehicle 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: lateral and longitudinal acceleration shall respect maximum and standard deviation values as calculated in paragraph 1.11.7. of this Annex and shall respect specifications defined in paragraph 1.6.13.3. of this Annex;
- (c) If more than 1500 km GNSS acceleration data are missing for the candidate tyre, the test for this candidate tyre is invalid;
- (d) If more than 1500 km GNSS acceleration data are missing for the reference tyre, the whole test is invalid;
- (e) Vehicle 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<sub>10</sub>) 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<sub>20</sub>) 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<sup>2</sup> 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 repairable 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 normal reference tyre abrasion level as follows:

$$ALTT_{20} = ALRT + S_s \cdot (20 - \bar{T})$$

where  $\bar{T}$  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 Winter reference tyre abrasion level as follows:

$$ALTT_{10} = ALRT + S_w \cdot (10 - \bar{T})$$

where  $\bar{T}$  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 the beginning of the test (Front axle TOE and camber, rear axle TOE and camber), in loaded condition;
- (e) Vehicle tuning at each intermediate measurement of the test (Front axle TOE and camber, rear axle TOE and camber), in loaded condition;
- (f) Vehicle tuning at the end of the test (Front axle TOE and camber, rear axle TOE and camber), in loaded condition;
- (g) Rim width (7.5");
- (h) Cold inflation pressure at the fitment;
- (i) Cold inflation pressure at 50 per cent of the test;
- (j) Cold inflation pressure at the end to the test;
- (k) Balancing mass at the beginning of the test;
- (l) Balancing mass at the end of the test;
- (m) Initial tyre mass (*MRTSi*) for each reference tyre;
- (n) Final tyre mass (*MRTFi*) for each reference tyre;
- (o) Abrasion level in mg/km/t normalized at 20 °C
- (p) Distance ran for each reference tyre;
- (q) Standard deviation of longitudinal acceleration for the vehicle fitted with reference tyre;
- (r) Standard deviation of lateral acceleration for the vehicle fitted with reference tyre;
- (s) Percentage of distance covered over the maximum longitudinal acceleration for the vehicle fitted with reference tyre;
- (t) Percentage of distance covered over the maximum lateral acceleration for the vehicle fitted with reference tyre;
- (u) Percentage of time travelled over each speed range (i.e. urban-like, regional-like, and highway-like);
- (v) Measured tyre load for each reference tyre;
- (w) 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 beginning 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;
  - (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 (*MCTSi*) for each candidate tyre;
  - (m) Final tyre mass (*MCTFi*) for each candidate tyre;
  - (n) Measured tyre load for each candidate tyre;
  - (o) Distance run for each candidate tyre;
  - (p) Standard deviation of longitudinal acceleration for the vehicle fitted with candidate tyre;
  - (q) Standard deviation of lateral acceleration for the vehicle fitted with candidate tyre;
  - (r) Percentage of distance covered under the maximum longitudinal acceleration for the vehicle fitted with candidate tyre;
  - (s) Percentage of distance covered under the maximum lateral acceleration for the vehicle fitted with candidate tyre;
  - (t) 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 11. 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  $\leq 13$ .
- 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".

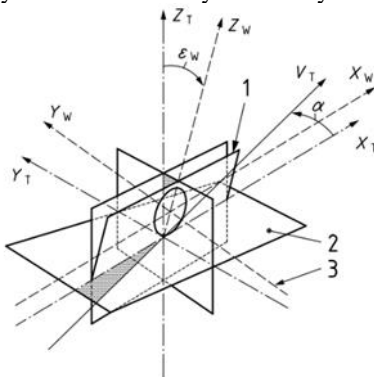
Normal reference tyre (225/45R17 94 XL ASTM F3676 - 23) shall be used for testing candidate tyres not for severe snow condition, means normal, snow and special tyres not bearing M+S nor 3PMSF marks.

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 ISO13473-1.

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 2.5.2.

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.

<i>Symbol</i>	<i>Unit</i>	<i>Designation</i>
T	No dimension	Candidate tyre
R	No dimension	Reference tyre
Fz	N	Vertical load
Fy	N	Lateral force
Fx	N	Longitudinal force
r <sub>L</sub>	m	Loaded radius
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  $\pm$  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:  $\pm 50\text{N}$  or 1 per cent whichever is greater;
- (d) Fy:  $\pm 100\text{N}$  or 5 per cent whichever is greater, for the difference between input peaks and actually generated peaks;
- (e) Fx:  $\pm 100\text{N}$  or 5 per cent whichever is greater, for the difference between input peaks and actually generated peaks;
- (f) My:  $\pm 40\text{Nm}$  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  $\mu\text{m}$  to 100  $\mu\text{m}$ .

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  $\pm 10$  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 less/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 ~~is~~ 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  $\pm 2$  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  $F_z$  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	CI <sup>a</sup>	
	Standard load or light load	Reinforced or extra load

Load -% of maximum load capacity	80	80
Inflation pressure <sup>b</sup> (kPa)	210	250
<sup>a</sup> 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. <sup>b</sup> 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 5000 km. The total distance of an actual test shall not differ more than  $\pm 5$  per cent from the total input distance;
- (c) The reference tyre shall be mounted on a 7.5 Rim width code rim. 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 ( $0^\circ$ ).

#### 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  $25^\circ\text{C} \pm 5^\circ\text{C}$ . 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  $2^\circ$ .

2.6.5. Mass Measurement

The mass of tyre shall be measured before and after 5000 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 4 of this Annex. The Appendix 4 test condition of 250 km is defined as one test cycle, and the test cycle shall be repeated 20 times until 5000 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 2500 km. The direction of rotation shall remain constant throughout the test.

A visual inspection of the tyres is recommended after the completion of 2500 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 (1000 km) – T (2000 km) – R (2000 km) – T (2000 km) – R (2000 km) – T (1000 km)

Repeat a set of Appendix 3 input conditions 4 times for 1000 km and 8 times for 2000 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  $F_z$  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  $0.125 \text{ m/s}^2$  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

<i>Item</i>	<i>Requirements</i>
(a) Test speed	Sampling frequency $\geq 1\text{Hz}$
(b) Tyre normal force to the drum surface	Sampling frequency $\geq 1\text{Hz}$
(c) Test inflation pressure: initial and end of the test, as defined in 2.6.3	Shall measure : <ul style="list-style-type: none"> <li>• Before starting the test;</li> <li>• 3 or more hours after end of the test.</li> </ul> Interim measurement during test is optional
(d) Ambient temperature measured in $^{\circ}\text{C}$ , $t_{\text{amb}}$	Sampling frequency $\geq 1\text{Hz}$

(e) Lateral force applied to the test tyre during the test	Sampling frequency $\geq 10$ Hz
(f) Longitudinal force or torque applied to the test tyre during the test	Sampling frequency $\geq 10$ Hz
(g) Mass of tyre	Shall measure : <ul style="list-style-type: none"> <li>• Before starting the test;</li> <li>• 3 or more hours after end of the test.</li> </ul> Interim measurement during test is optional
(h) MPD and micro-roughness of the test surface;	Shall measure at the timings of : <ul style="list-style-type: none"> <li>• Before starting the test;</li> <li>• 3 or more hours after end of the test.</li> </ul> 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<sup>2</sup> 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)	$RMS_{Gx} = 0.059$	$\pm 5$ %
Fy	RMS (a) of G(y)	$RMS_{Gy} = 0.074$	$\pm 5$ %
Fx and Fy	RMS (a) of G(x, y)	$RMS_{Gxy} = 0.095$	$\pm 5$ %
Fz	RMS of Fz applied filter divided by Fz nominal	Average of Fz	$\pm 50$ N or $\pm 1$ %, whichever is greater
<p>Note 1 to entry:</p> <p>(a) For the whole test of total 5000 km, calculate the Root Mean Square (RMS) of G(x) and G(y) using the equations below:</p> $RMS_{Gx} = \sqrt{\frac{1}{N} \times \sum_{i=1}^N \left( \frac{Fx_i}{Fz_i} \right)^2}$			

$$RMS_{Gy} = \sqrt{\frac{1}{N} \times \sum_{i=1}^N \left( \frac{Fy_i}{Fz_i} \right)^2}$$

$$RMS_{Gxy} = \sqrt{\frac{1}{N} \times \sum_{i=1}^N \frac{(Fx_i)^2 + (Fy_i)^2}{(Average\ of\ Fz)^2}}$$

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:

$$MIT = MT_b - MT_a$$

$$MIR = MR_b - MR_a$$

Where:

$MIT$  is Mass loss of candidate tyre, in grams

$MIR$  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,

$$ArT = MIT (g)/DT(km)/Fz,T(t) \times 1000 (mg/kg)$$

$ArR$  Normalized abrasion rate (mg/km/t) of reference tyre,

$$ArR = MIR (g)/DR(km)/Fz,R(t) \times 1000 (mg/kg)$$

$DT$  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

### Accelerations calculation

#### 1. Input for calculation

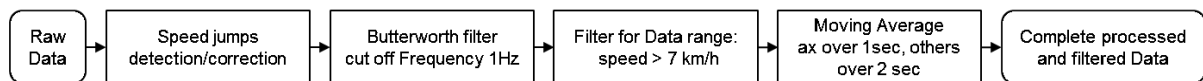
##### 1.1. Required parameters

The following parameters are required for the calculation of longitudinal and lateral acceleration:

- (a) The vehicle velocity ( $v$ ), [m/s]
- (b) The longitudinal acceleration ( $a_{\text{longitudinal}}$ ), [m/s<sup>2</sup>]
- (c) The lateral acceleration ( $a_{\text{lateral}}$ ), [m/s<sup>2</sup>]

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<sup>2</sup> for the maximum longitudinal acceleration is defined. That means, that a speed change of maximum  $9 \text{ m/s}^2 \cdot t_{\text{sampling}}$  is still plausible.

A speed jump will be detected if there is a speed difference of  $2 \cdot \Delta \text{speed}_{\text{possible}}$ . 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:

$$S_{longitudinal} = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^N (a_{longitudinal,i} - \mu_{longitudinal})^2}$$

with  $\mu_{longitudinal} = \frac{1}{N} \sum_{i=1}^N a_{longitudinal,i}$

$$S_{lateral} = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^N (a_{lateral,i} - \mu_{lateral})^2}$$

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 accelerations - 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 ( $S_{\text{longitudinal}}$  ;  $S_{\text{lateral}}$ ) for each segment, following the method described in paragraph 1. of this appendix;
- (d) For each segment with ( $S_{\text{longitudinal}}$  ;  $S_{\text{lateral}}$ ) 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 report example for 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								
Tyre brand								
Tyre pattern								
Tyre size designation								
Tyre load index								
Tyre speed index								
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

### Input of test cycle

In order to calculate the input forces  $F_x$  and  $F_y$ , longitudinal and lateral acceleration indices, as  $G(x)$  and  $G(y)$  respectively, are introduced as below.

For torque control testing machine, tyre torque ( $M_y$ ) is calculated with longitudinal force ( $F_x$ ) and loaded radius ( $RL$ ) following the equations provided below:

$$F_x = F_z \times G(x) \text{ or } M_y = \text{Test load}(F_z) \times G(x) \times RL$$

$$F_y = F_z \times G(y)$$

$F_z$  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 ( $g = 9.80665 \text{ m/s}^2$ ). Alternatively, the local earth gravity may be defined.

Table A1 defines the time,  $G(x)$ ,  $G(y)$ , and speed of test cycle. In Table T1,  $T$  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  $F_x$  and  $F_y$  will also change linearly from one point to another. The following graphs show samples of linear change for  $F_x$  or  $F_y$  with respect to  $T$ .

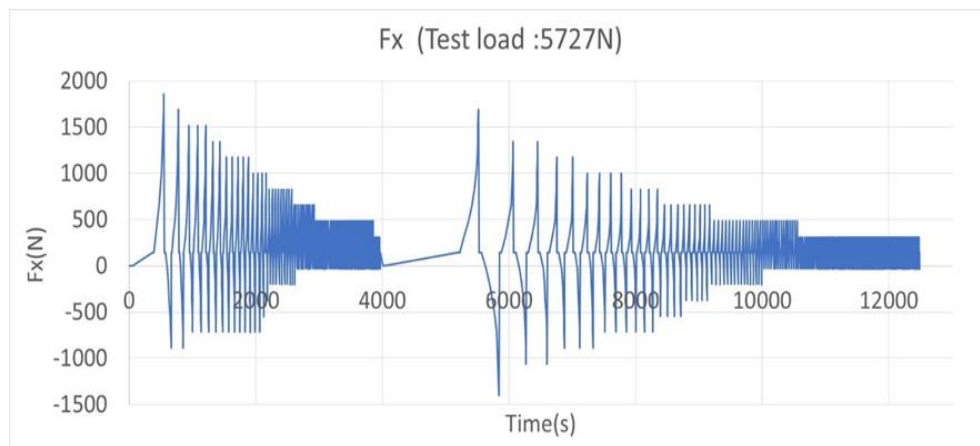
$T$  means the driving time from starting test.

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.

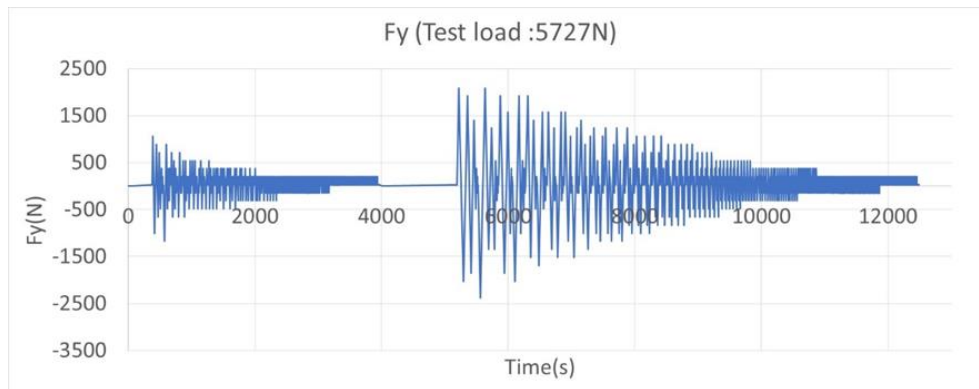
#### Graph A.1

Example of  $F_x$ , with a test load of 5727N



**Graph A.2**

Example of  $F_y$ , with a test load of 5727N



**Table A1.**

Input of test cycle

$T$	$v$	$G(x)$	$G(y)$
(s)	(kph)		
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
1001.5	100	-0.125	0.035
1006.5	100	0.025	0.005
1014.1	100	0.025	0.095
1031.8	100	0.055	-0.085
1049.5	100	0.085	0.095
1059.6	100	0.115	-0.025
1067.1	100	0.145	0.035
1072.2	100	0.175	0.005
1077.2	100	0.205	0.035
1082.3	100	0.235	0.005
1084.8	100	0.265	0.005
1092.4	100	0.025	0.005
1100.0	100	0.025	-0.085
1112.6	100	-0.005	0.065
1120.2	100	-0.035	-0.025
1125.3	100	-0.065	0.035
1130.3	100	-0.095	0.005
1135.4	100	-0.125	0.035
1140.4	100	0.025	0.005
1148.0	100	0.025	0.095
1165.7	100	0.055	-0.085
1180.8	100	0.085	0.065
1188.4	100	0.115	-0.025
1193.5	100	0.145	0.035
1198.5	100	0.175	0.005
1203.6	100	0.205	0.035
1206.1	100	0.235	0.005
1208.6	100	0.265	0.005

1216.2	100	0.025	0.005
1223.8	100	0.025	-0.085
1236.4	100	-0.005	0.065
1241.5	100	-0.035	0.005
1246.5	100	-0.065	0.035
1251.6	100	-0.095	0.005
1256.6	100	-0.125	0.035
1261.7	100	0.025	0.005
1269.3	100	0.025	0.095
1284.4	100	0.055	-0.085
1299.6	100	0.085	0.065
1307.2	100	0.115	-0.025
1312.2	100	0.145	0.035
1317.3	100	0.175	0.005
1322.3	100	0.205	0.035
1324.8	100	0.235	0.005
1331.6	100	0.025	0.005
1339.2	100	0.025	-0.085
1351.8	100	-0.005	0.065
1356.8	100	-0.035	0.005
1361.9	100	-0.065	0.035
1366.9	100	-0.095	0.005
1372.0	100	-0.125	0.035
1377.1	100	0.025	0.005
1382.1	100	0.025	0.065
1397.3	100	0.055	-0.085
1409.9	100	0.085	0.065
1417.5	100	0.115	-0.025
1422.5	100	0.145	0.035
1427.6	100	0.175	0.005
1432.6	100	0.205	0.035
1435.2	100	0.235	0.005
1441.9	100	0.025	0.005
1447.0	100	0.025	-0.055
1457.1	100	-0.005	0.065
1462.1	100	-0.035	0.005
1467.2	100	-0.065	0.035



1472.2	100	-0.095	0.005
1477.3	100	-0.125	0.035
1482.3	100	0.025	0.005
1487.4	100	0.025	0.065
1502.5	100	0.055	-0.085
1515.2	100	0.085	0.065
1522.7	100	0.115	-0.025
1527.8	100	0.145	0.035
1532.9	100	0.175	0.005
1535.4	100	0.205	0.005
1541.3	100	0.025	0.005
1546.3	100	0.025	-0.055
1556.4	100	-0.005	0.065
1561.5	100	-0.035	0.005
1566.5	100	-0.065	0.035
1571.6	100	-0.095	0.005
1576.6	100	-0.125	0.035
1581.7	100	0.025	0.005
1586.8	100	0.025	0.065
1601.9	100	0.055	-0.085
1614.5	100	0.085	0.065
1619.6	100	0.115	0.005
1624.6	100	0.145	0.035
1629.7	100	0.175	0.005
1632.2	100	0.205	0.005
1638.1	100	0.025	0.005
1643.2	100	0.025	-0.055
1650.8	100	-0.005	0.035
1655.8	100	-0.035	0.005
1660.9	100	-0.065	0.035
1663.4	100	-0.095	0.005
1665.9	100	-0.125	0.005
1671.0	100	0.025	0.005
1676.0	100	0.025	0.065
1691.2	100	0.055	-0.085
1703.8	100	0.085	0.065
1708.9	100	0.115	0.005

1713.9	100	0.145	0.035
1719.0	100	0.175	0.005
1721.5	100	0.205	0.005
1727.4	100	0.025	0.005
1732.4	100	0.025	-0.055
1740.0	100	-0.005	0.035
1745.1	100	-0.035	0.005
1747.6	100	-0.065	0.005
1750.1	100	-0.095	0.005
1752.7	100	-0.125	0.005
1757.7	100	0.025	0.005
1762.8	100	0.025	0.065
1775.4	100	0.055	-0.055
1788.0	100	0.085	0.065
1793.1	100	0.115	0.005
1798.1	100	0.145	0.035
1800.7	100	0.175	0.005
1803.2	100	0.205	0.005
1809.1	100	0.025	0.005
1814.1	100	0.025	-0.055
1821.7	100	-0.005	0.035
1826.8	100	-0.035	0.005
1829.3	100	-0.065	0.005
1831.8	100	-0.095	0.005
1834.3	100	-0.125	0.005
1839.4	100	0.025	0.005
1844.5	100	0.025	0.065
1857.1	100	0.055	-0.055
1867.2	100	0.085	0.035
1872.2	100	0.115	0.005
1877.3	100	0.145	0.035
1879.8	100	0.175	0.005
1882.3	100	0.205	0.005
1888.2	100	0.025	0.005
1893.3	100	0.025	-0.055
1900.9	100	-0.005	0.035
1905.9	100	-0.035	0.005

1908.5	100	-0.065	0.005
1911.0	100	-0.095	0.005
1913.5	100	-0.125	0.005
1918.6	100	0.025	0.005
1923.6	100	0.025	0.065
1936.2	100	0.055	-0.055
1946.4	100	0.085	0.035
1951.4	100	0.115	0.005
1956.5	100	0.145	0.035
1959.0	100	0.175	0.005
1964.0	100	0.025	0.005
1969.1	100	0.025	-0.055
1976.7	100	-0.005	0.035
1981.7	100	-0.035	0.005
1984.2	100	-0.065	0.005
1986.8	100	-0.095	0.005
1989.3	100	-0.125	0.005
1994.4	100	0.025	0.005
1999.4	100	0.025	0.065
2009.5	100	0.055	-0.055
2019.6	100	0.085	0.035
2024.7	100	0.115	0.005
2029.7	100	0.145	0.035
2032.3	100	0.175	0.005
2037.3	100	0.025	0.005
2042.4	100	0.025	-0.055
2049.9	100	-0.005	0.035
2055.0	100	-0.035	0.005
2057.5	100	-0.065	0.005
2060.0	100	-0.095	0.005
2062.6	100	-0.125	0.005
2067.6	100	0.025	0.005
2070.1	100	0.025	0.035
2080.3	100	0.055	-0.055
2087.8	100	0.085	0.035
2092.9	100	0.115	0.005
2097.9	100	0.145	0.035

2100.5	100	0.175	0.005
2105.5	100	0.025	0.005
2108.0	100	0.025	-0.025
2115.6	100	-0.005	0.035
2120.7	100	-0.035	0.005
2123.2	100	-0.065	0.005
2125.7	100	-0.095	0.005
2129.9	100	0.025	0.005
2132.5	100	0.025	0.035
2142.6	100	0.055	-0.055
2150.2	100	0.085	0.035
2155.2	100	0.115	0.005
2160.3	100	0.145	0.035
2162.8	100	0.175	0.005
2167.8	100	0.025	0.005
2170.4	100	0.025	-0.025
2177.9	100	-0.005	0.035
2180.5	100	-0.035	0.005
2183.0	100	-0.065	0.005
2186.4	100	0.025	0.005
2188.9	100	0.025	0.035
2199.0	100	0.055	-0.055
2206.6	100	0.085	0.035
2211.6	100	0.115	0.005
2214.2	100	0.145	0.005
2218.4	100	0.025	0.005
2220.9	100	0.025	-0.025
2228.5	100	-0.005	0.035
2231.0	100	-0.035	0.005
2233.5	100	0.025	0.005
2236.1	100	0.025	0.035
2246.2	100	0.055	-0.055
2253.7	100	0.085	0.035
2258.8	100	0.115	0.005
2261.3	100	0.145	0.005
2265.5	100	0.025	0.005
2268.1	100	0.025	-0.025

2275.6	100	-0.005	0.035
2278.2	100	-0.035	0.005
2280.7	100	0.025	0.005
2283.2	100	0.025	0.035
2293.3	100	0.055	-0.055
2300.9	100	0.085	0.035
2306.0	100	0.115	0.005
2308.5	100	0.145	0.005
2312.7	100	0.025	0.005
2315.2	100	0.025	-0.025
2322.8	100	-0.005	0.035
2325.3	100	-0.035	0.005
2327.8	100	0.025	0.005
2330.4	100	0.025	0.035
2340.5	100	0.055	-0.055
2348.1	100	0.085	0.035
2353.1	100	0.115	0.005
2355.6	100	0.145	0.005
2359.9	100	0.025	0.005
2362.4	100	0.025	-0.025
2370.0	100	-0.005	0.035
2372.5	100	-0.035	0.005
2375.0	100	0.025	0.005
2377.5	100	0.025	0.035
2385.1	100	0.055	-0.025
2392.7	100	0.085	0.035
2397.7	100	0.115	0.005
2400.3	100	0.145	0.005
2404.5	100	0.025	0.005
2407.0	100	0.025	-0.025
2412.1	100	-0.005	0.035
2414.6	100	-0.035	0.005
2417.1	100	0.025	0.005
2419.6	100	0.025	0.035
2427.2	100	0.055	-0.025
2434.8	100	0.085	0.035
2439.9	100	0.115	0.005

2442.4	100	0.145	0.005
2446.6	100	0.025	0.005
2449.1	100	0.025	-0.025
2454.2	100	-0.005	0.035
2456.7	100	-0.035	0.005
2459.2	100	0.025	0.005
2461.8	100	0.025	0.035
2469.3	100	0.055	-0.025
2476.9	100	0.085	0.035
2482.0	100	0.115	0.005
2484.5	100	0.145	0.005
2488.7	100	0.025	0.005
2491.2	100	0.025	-0.025
2496.3	100	-0.005	0.035
2498.8	100	-0.035	0.005
2501.3	100	0.025	0.005
2503.9	100	0.025	0.035
2511.4	100	0.055	-0.025
2519.0	100	0.085	0.035
2524.1	100	0.115	0.005
2526.6	100	0.145	0.005
2530.8	100	0.025	0.005
2533.3	100	0.025	-0.025
2538.4	100	-0.005	0.035
2540.9	100	-0.035	0.005
2543.4	100	0.025	0.005
2546.0	100	0.025	0.035
2553.5	100	0.055	-0.025
2561.1	100	0.085	0.035
2563.7	100	0.115	0.005
2566.2	100	0.145	0.005
2570.4	100	0.025	0.005
2572.9	100	0.025	-0.025
2578.0	100	-0.005	0.035
2580.5	100	-0.035	0.005
2583.0	100	0.025	0.005
2585.5	100	0.025	0.035

2593.1	100	0.055	-0.025
2600.7	100	0.085	0.035
2603.2	100	0.115	0.005
2606.6	100	0.025	0.005
2609.1	100	0.025	-0.025
2614.2	100	-0.005	0.035
2616.7	100	-0.035	0.005
2619.2	100	0.025	0.005
2621.8	100	0.025	0.035
2629.3	100	0.055	-0.025
2636.9	100	0.085	0.035
2639.4	100	0.115	0.005
2642.8	100	0.025	0.005
2645.3	100	0.025	-0.025
2650.4	100	-0.005	0.035
2652.1	100	0.025	0.005
2654.6	100	0.025	0.035
2662.2	100	0.055	-0.025
2669.8	100	0.085	0.035
2672.3	100	0.115	0.005
2675.7	100	0.025	0.005
2678.2	100	0.025	-0.025
2683.2	100	-0.005	0.035
2684.9	100	0.025	0.005
2687.4	100	0.025	0.035
2695.0	100	0.055	-0.025
2702.6	100	0.085	0.035
2705.1	100	0.115	0.005
2708.5	100	0.025	0.005
2711.0	100	0.025	-0.025
2716.1	100	-0.005	0.035
2717.8	100	0.025	0.005
2720.3	100	0.025	0.035
2727.9	100	0.055	-0.025
2735.5	100	0.085	0.035
2738.0	100	0.115	0.005
2741.3	100	0.025	0.005

2743.9	100	0.025	-0.025
2748.9	100	-0.005	0.035
2750.6	100	0.025	0.005
2753.1	100	0.025	0.035
2760.7	100	0.055	-0.025
2765.8	100	0.085	0.035
2768.3	100	0.115	0.005
2771.7	100	0.025	0.005
2774.2	100	0.025	-0.025
2779.2	100	-0.005	0.035
2780.9	100	0.025	0.005
2783.5	100	0.025	0.035
2791.0	100	0.055	-0.025
2796.1	100	0.085	0.035
2798.6	100	0.115	0.005
2802.0	100	0.025	0.005
2804.5	100	0.025	-0.025
2809.6	100	-0.005	0.035
2811.2	100	0.025	0.005
2813.8	100	0.025	0.035
2821.4	100	0.055	-0.025
2826.4	100	0.085	0.035
2828.9	100	0.115	0.005
2832.3	100	0.025	0.005
2834.8	100	0.025	-0.025
2839.9	100	-0.005	0.035
2841.6	100	0.025	0.005
2844.1	100	0.025	0.035
2851.7	100	0.055	-0.025
2856.7	100	0.085	0.035
2859.2	100	0.115	0.005
2862.6	100	0.025	0.005
2865.1	100	0.025	-0.025
2870.2	100	-0.005	0.035
2871.9	100	0.025	0.005
2874.4	100	0.025	0.035
2882.0	100	0.055	-0.025

2887.0	100	0.085	0.035
2889.6	100	0.115	0.005
2892.9	100	0.025	0.005
2895.5	100	0.025	-0.025
2900.5	100	-0.005	0.035
2902.2	100	0.025	0.005
2904.7	100	0.025	0.035
2912.3	100	0.055	-0.025
2917.4	100	0.085	0.035
2919.9	100	0.115	0.005
2923.3	100	0.025	0.005
2925.8	100	0.025	-0.025
2930.8	100	-0.005	0.035
2932.5	100	0.025	0.005
2935.0	100	0.025	0.035
2942.6	100	0.055	-0.025
2947.7	100	0.085	0.035
2950.2	100	0.025	0.005
2952.7	100	0.025	-0.025
2957.8	100	-0.005	0.035
2959.5	100	0.025	0.005
2962.0	100	0.025	0.035
2969.6	100	0.055	-0.025
2974.6	100	0.085	0.035
2977.2	100	0.025	0.005
2979.7	100	0.025	-0.025
2984.7	100	-0.005	0.035
2986.4	100	0.025	0.005
2988.9	100	0.025	0.035
2996.5	100	0.055	-0.025
3001.6	100	0.085	0.035
3004.1	100	0.025	0.005
3006.6	100	0.025	-0.025
3011.7	100	-0.005	0.035
3013.4	100	0.025	0.005
3015.9	100	0.025	0.035
3023.5	100	0.055	-0.025

3028.5	100	0.085	0.035
3031.0	100	0.025	0.005
3036.1	100	0.025	0.005
3041.2	100	-0.005	0.035
3042.8	100	0.025	0.005
3045.4	100	0.025	0.035
3052.9	100	0.055	-0.025
3058.0	100	0.085	0.035
3060.5	100	0.025	0.005
3065.6	100	0.025	0.005
3070.6	100	-0.005	0.035
3072.3	100	0.025	0.005
3074.8	100	0.025	0.035
3082.4	100	0.055	-0.025
3087.5	100	0.085	0.035
3090.0	100	0.025	0.005
3095.1	100	0.025	0.005
3100.1	100	-0.005	0.035
3101.8	100	0.025	0.005
3104.3	100	0.025	0.035
3111.9	100	0.055	-0.025
3116.9	100	0.085	0.035
3119.5	100	0.025	0.005
3124.5	100	0.025	0.005
3129.6	100	-0.005	0.035
3131.3	100	0.025	0.005
3133.8	100	0.025	0.035
3141.4	100	0.055	-0.025
3146.4	100	0.085	0.035
3149.0	100	0.025	0.005
3154.0	100	0.025	0.005
3159.1	100	-0.005	0.035
3160.7	100	0.025	0.005
3163.3	100	0.025	0.035
3170.8	100	0.055	-0.025
3175.9	100	0.085	0.035
3178.4	100	0.025	0.005

3183.5	100	0.025	0.005
3188.5	100	-0.005	0.035
3190.2	100	0.025	0.005
3192.7	100	0.025	0.035
3197.8	100	0.055	0.005
3202.8	100	0.085	0.035
3205.4	100	0.025	0.005
3210.4	100	0.025	0.005
3215.5	100	-0.005	0.035
3217.2	100	0.025	0.005
3219.7	100	0.025	0.035
3224.7	100	0.055	0.005
3229.8	100	0.085	0.035
3232.3	100	0.025	0.005
3237.4	100	0.025	0.005
3242.4	100	-0.005	0.035
3244.1	100	0.025	0.005
3246.6	100	0.025	0.035
3251.7	100	0.055	0.005
3256.7	100	0.085	0.035
3259.3	100	0.025	0.005
3264.3	100	0.025	0.005
3269.4	100	-0.005	0.035
3271.1	100	0.025	0.005
3273.6	100	0.025	0.035
3278.6	100	0.055	0.005
3283.7	100	0.085	0.035
3286.2	100	0.025	0.005
3291.3	100	0.025	0.005
3296.3	100	-0.005	0.035
3298.0	100	0.025	0.005
3300.5	100	0.025	0.035
3305.6	100	0.055	0.005
3310.6	100	0.085	0.035
3313.2	100	0.025	0.005
3318.2	100	0.025	0.005
3323.3	100	-0.005	0.035

3325.0	100	0.025	0.005
3327.5	100	0.025	0.035
3332.5	100	0.055	0.005
3335.1	100	0.085	0.005
3337.6	100	0.025	0.005
3342.6	100	0.025	0.005
3347.7	100	-0.005	0.035
3349.4	100	0.025	0.005
3351.9	100	0.025	0.035
3357.0	100	0.055	0.005
3359.5	100	0.085	0.005
3362.0	100	0.025	0.005
3367.1	100	0.025	0.005
3372.1	100	-0.005	0.035
3373.8	100	0.025	0.005
3376.3	100	0.025	0.035
3381.4	100	0.055	0.005
3383.9	100	0.085	0.005
3386.4	100	0.025	0.005
3391.5	100	0.025	0.005
3394.0	100	-0.005	0.005
3395.7	100	0.025	0.005
3398.2	100	0.025	0.035
3403.3	100	0.055	0.005
3405.8	100	0.085	0.005
3408.3	100	0.025	0.005
3413.4	100	0.025	0.005
3415.9	100	-0.005	0.005
3417.6	100	0.025	0.005
3420.1	100	0.025	0.035
3425.2	100	0.055	0.005
3427.7	100	0.085	0.005
3430.2	100	0.025	0.005
3435.3	100	0.025	0.005
3437.8	100	-0.005	0.005
3439.5	100	0.025	0.005
3442.0	100	0.025	0.035

3447.1	100	0.055	0.005
3449.6	100	0.085	0.005
3452.1	100	0.025	0.005
3457.2	100	0.025	0.005
3459.7	100	-0.005	0.005
3461.4	100	0.025	0.005
3463.9	100	0.025	0.035
3469.0	100	0.055	0.005
3471.5	100	0.085	0.005
3474.0	100	0.025	0.005
3479.1	100	0.025	0.005
3481.6	100	-0.005	0.005
3483.3	100	0.025	0.005
3485.8	100	0.025	0.035
3490.9	100	0.055	0.005
3493.4	100	0.085	0.005
3495.9	100	0.025	0.005
3501.0	100	0.025	0.005
3503.5	100	-0.005	0.005
3505.2	100	0.025	0.005
3507.7	100	0.025	0.035
3512.8	100	0.055	0.005
3515.3	100	0.085	0.005
3517.8	100	0.025	0.005
3522.9	100	0.025	0.005
3525.4	100	-0.005	0.005
3527.1	100	0.025	0.005
3529.6	100	0.025	0.035
3534.7	100	0.055	0.005
3537.2	100	0.085	0.005
3539.7	100	0.025	0.005
3544.8	100	0.025	0.005
3547.3	100	-0.005	0.005
3549.0	100	0.025	0.005
3551.5	100	0.025	0.035
3556.6	100	0.055	0.005
3559.1	100	0.085	0.005

3561.6	100	0.025	0.005
3566.7	100	0.025	0.005
3569.2	100	-0.005	0.005
3570.9	100	0.025	0.005
3573.4	100	0.025	0.035
3578.5	100	0.055	0.005
3581.0	100	0.085	0.005
3583.5	100	0.025	0.005
3588.6	100	0.025	0.005
3591.1	100	-0.005	0.005
3592.8	100	0.025	0.005
3595.3	100	0.025	0.035
3600.3	100	0.055	0.005
3602.9	100	0.085	0.005
3605.4	100	0.025	0.005
3610.5	100	0.025	0.005
3613.0	100	-0.005	0.005
3614.7	100	0.025	0.005
3617.2	100	0.025	0.035
3619.7	100	0.055	0.005
3622.2	100	0.085	0.005
3624.8	100	0.025	0.005
3629.8	100	0.025	0.005
3632.3	100	-0.005	0.005
3634.0	100	0.025	0.005
3636.6	100	0.025	0.035
3639.1	100	0.055	0.005
3641.6	100	0.085	0.005
3644.1	100	0.025	0.005
3649.2	100	0.025	0.005
3651.7	100	-0.005	0.005
3653.4	100	0.025	0.005
3655.9	100	0.025	0.035
3658.5	100	0.055	0.005
3661.0	100	0.085	0.005
3663.5	100	0.025	0.005
3668.6	100	0.025	0.005

3671.1	100	-0.005	0.005
3672.8	100	0.025	0.005
3675.3	100	0.025	0.035
3677.8	100	0.055	0.005
3680.4	100	0.085	0.005
3682.9	100	0.025	0.005
3687.9	100	0.025	0.005
3690.5	100	-0.005	0.005
3692.1	100	0.025	0.005
3694.7	100	0.025	0.035
3697.2	100	0.055	0.005
3699.7	100	0.085	0.005
3702.2	100	0.025	0.005
3707.3	100	0.025	0.005
3709.8	100	-0.005	0.005
3711.5	100	0.025	0.005
3714.0	100	0.025	0.035
3716.6	100	0.055	0.005
3719.1	100	0.085	0.005
3721.6	100	0.025	0.005
3726.7	100	0.025	0.005
3729.2	100	-0.005	0.005
3730.9	100	0.025	0.005
3733.4	100	0.025	0.035
3735.9	100	0.055	0.005
3738.5	100	0.085	0.005
3741.0	100	0.025	0.005
3746.0	100	0.025	0.005
3748.6	100	-0.005	0.005
3750.3	100	0.025	0.005
3752.8	100	0.025	0.035
3755.3	100	0.055	0.005
3757.8	100	0.085	0.005
3760.4	100	0.025	0.005
3765.4	100	0.025	0.005
3767.9	100	-0.005	0.005
3769.6	100	0.025	0.005

3772.1	100	0.025	0.035
3774.7	100	0.055	0.005
3777.2	100	0.085	0.005
3779.7	100	0.025	0.005
3784.8	100	0.025	0.005
3787.3	100	-0.005	0.005
3789.0	100	0.025	0.005
3791.5	100	0.025	0.035
3794.0	100	0.055	0.005
3796.6	100	0.085	0.005
3799.1	100	0.025	0.005
3804.1	100	0.025	0.005
3806.7	100	-0.005	0.005
3808.4	100	0.025	0.005
3810.9	100	0.025	0.035
3813.4	100	0.055	0.005
3815.9	100	0.085	0.005
3818.5	100	0.025	0.005
3823.5	100	0.025	0.005
3826.0	100	-0.005	0.005
3827.7	100	0.025	0.005
3830.3	100	0.025	0.035
3832.8	100	0.055	0.005
3835.3	100	0.085	0.005
3837.8	100	0.025	0.005
3842.9	100	0.025	0.005
3845.4	100	-0.005	0.005
3847.1	100	0.025	0.005
3849.6	100	0.025	0.035
3852.2	100	0.055	0.005
3854.7	100	0.085	0.005
3857.2	100	0.025	0.005
3862.3	100	0.025	0.005
3864.8	100	-0.005	0.005
3866.5	100	0.025	0.005
3869.0	100	0.025	0.035
3871.5	100	0.055	0.005



3873.2	100	0.025	0.005
3878.3	100	0.025	0.005
3880.8	100	-0.005	0.005
3882.5	100	0.025	0.005
3885.0	100	0.025	0.035
3887.5	100	0.055	0.005
3889.2	100	0.025	0.005
3894.3	100	0.025	0.005
3896.8	100	-0.005	0.005
3898.5	100	0.025	0.005
3901.0	100	0.025	0.035
3903.5	100	0.055	0.005
3905.2	100	0.025	0.005
3910.3	100	0.025	0.005
3912.8	100	-0.005	0.005
3914.5	100	0.025	0.005
3917.0	100	0.025	0.035
3919.5	100	0.055	0.005
3921.2	100	0.025	0.005
3926.3	100	0.025	0.005
3928.8	100	-0.005	0.005
3930.5	100	0.025	0.005
3933.0	100	0.025	0.035
3935.5	100	0.055	0.005
3937.2	100	0.025	0.005
3942.3	100	0.025	0.005
3944.8	100	-0.005	0.005
3946.5	100	0.025	0.005
3951.5	100	0.025	0.005
3954.1	100	0.055	0.005
3955.7	100	0.025	0.005
3960.8	100	0.025	0.005
3963.3	100	-0.005	0.005
3965.0	100	0.025	0.005
4015.0	60	0.000	0.000
5188.3	60	0.025	0.005
5221.7	60	0.025	0.365

5291.3	60	0.055	-0.355
5358.1	60	0.085	0.335
5416.6	60	0.115	-0.325
5458.3	60	0.145	0.245
5486.2	60	0.175	-0.085
5497.3	60	0.205	0.065
5505.6	60	0.235	-0.025
5511.2	60	0.265	0.035
5514.0	60	0.295	0.005
5523.3	60	0.025	0.005
5562.2	60	0.025	-0.415
5637.4	60	-0.005	0.365
5693.1	60	-0.035	-0.235
5737.6	60	-0.065	0.215
5779.3	60	-0.095	-0.235
5801.6	60	-0.125	0.095
5818.3	60	-0.155	-0.055
5826.7	60	-0.185	0.035
5835.0	60	-0.215	-0.025
5837.8	60	-0.245	0.005
5847.1	60	0.025	0.005
5877.7	60	0.025	0.335
5941.7	60	0.055	-0.325
5991.8	60	0.085	0.275
6033.6	60	0.115	-0.175
6047.5	60	0.145	0.065
6055.8	60	0.175	-0.025
6061.4	60	0.205	0.035
6067.0	60	0.235	0.005
6074.4	60	0.025	0.005
6107.8	60	0.025	-0.355
6169.0	60	-0.005	0.335
6202.4	60	-0.035	-0.175
6227.5	60	-0.065	0.095
6246.9	60	-0.095	-0.085
6258.1	60	-0.125	0.065
6266.4	60	-0.155	-0.025

6269.2	60	-0.185	0.005
6276.6	60	0.025	0.005
6307.3	60	0.025	0.335
6360.1	60	0.055	-0.265
6404.7	60	0.085	0.245
6429.7	60	0.115	-0.085
6440.9	60	0.145	0.035
6446.4	60	0.175	0.005
6452.0	60	0.205	0.035
6454.8	60	0.235	0.005
6462.2	60	0.025	0.005
6490.0	60	0.025	-0.295
6542.9	60	-0.005	0.275
6562.4	60	-0.035	-0.085
6576.3	60	-0.065	0.065
6587.4	60	-0.095	-0.055
6595.8	60	-0.125	0.035
6601.4	60	-0.155	0.005
6604.1	60	-0.185	0.005
6611.6	60	0.025	0.005
6636.6	60	0.025	0.275
6686.7	60	0.055	-0.235
6725.7	60	0.085	0.215
6739.6	60	0.115	-0.055
6745.2	60	0.145	0.035
6750.7	60	0.175	0.005
6753.5	60	0.205	0.005
6760.0	60	0.025	0.005
6785.1	60	0.025	-0.265
6835.2	60	-0.005	0.275
6849.1	60	-0.035	-0.055
6857.4	60	-0.065	0.035
6865.8	60	-0.095	-0.025
6871.3	60	-0.125	0.035
6874.1	60	-0.155	0.005
6880.6	60	0.025	0.005
6905.7	60	0.025	0.275

6950.2	60	0.055	-0.205
6983.6	60	0.085	0.185
6994.7	60	0.115	-0.025
7000.3	60	0.145	0.035
7005.9	60	0.175	0.005
7008.7	60	0.205	0.005
7015.2	60	0.025	0.005
7040.2	60	0.025	-0.265
7082.0	60	-0.005	0.215
7093.1	60	-0.035	-0.025
7101.4	60	-0.065	0.035
7109.8	60	-0.095	-0.025
7115.4	60	-0.125	0.035
7118.1	60	-0.155	0.005
7124.6	60	0.025	0.005
7146.9	60	0.025	0.245
7185.9	60	0.055	-0.175
7213.7	60	0.085	0.155
7224.8	60	0.115	-0.025
7230.4	60	0.145	0.035
7233.2	60	0.175	0.005
7238.7	60	0.025	0.005
7261.0	60	0.025	-0.235
7297.2	60	-0.005	0.185
7305.5	60	-0.035	-0.025
7313.9	60	-0.065	0.035
7319.5	60	-0.095	0.005
7325.0	60	-0.125	0.035
7327.8	60	-0.155	0.005
7334.3	60	0.025	0.005
7353.8	60	0.025	0.215
7392.8	60	0.055	-0.175
7412.2	60	0.085	0.095
7420.6	60	0.115	-0.025
7426.2	60	0.145	0.035
7428.9	60	0.175	0.005
7434.5	60	0.025	0.005

7454.0	60	0.025	-0.205
7490.2	60	-0.005	0.185
7498.5	60	-0.035	-0.025
7506.9	60	-0.065	0.035
7512.4	60	-0.095	0.005
7515.2	60	-0.125	0.005
7520.8	60	0.025	0.005
7540.3	60	0.025	0.215
7576.5	60	0.055	-0.175
7595.9	60	0.085	0.095
7601.5	60	0.115	0.005
7607.1	60	0.145	0.035
7609.9	60	0.175	0.005
7615.4	60	0.025	0.005
7634.9	60	0.025	-0.205
7665.5	60	-0.005	0.155
7673.9	60	-0.035	-0.025
7679.4	60	-0.065	0.035
7685.0	60	-0.095	0.005
7687.8	60	-0.125	0.005
7693.4	60	0.025	0.005
7712.8	60	0.025	0.215
7749.0	60	0.055	-0.175
7765.7	60	0.085	0.095
7771.3	60	0.115	0.005
7774.1	60	0.145	0.005
7776.9	60	0.175	0.005
7782.4	60	0.025	0.005
7801.9	60	0.025	-0.205
7832.5	60	-0.005	0.155
7840.9	60	-0.035	-0.025
7846.4	60	-0.065	0.035
7849.2	60	-0.095	0.005
7852.0	60	-0.125	0.005
7857.6	60	0.025	0.005
7877.1	60	0.025	0.215
7910.5	60	0.055	-0.145

7924.4	60	0.085	0.065
7929.9	60	0.115	0.005
7932.7	60	0.145	0.005
7937.4	60	0.025	0.005
7954.1	60	0.025	-0.175
7984.7	60	-0.005	0.155
7993.0	60	-0.035	-0.025
7998.6	60	-0.065	0.035
8001.4	60	-0.095	0.005
8004.2	60	-0.125	0.005
8009.7	60	0.025	0.005
8026.4	60	0.025	0.185
8057.1	60	0.055	-0.145
8068.2	60	0.085	0.065
8073.8	60	0.115	0.005
8076.5	60	0.145	0.005
8081.2	60	0.025	0.005
8097.9	60	0.025	-0.175
8122.9	60	-0.005	0.125
8128.5	60	-0.035	0.005
8134.1	60	-0.065	0.035
8136.8	60	-0.095	0.005
8139.6	60	-0.125	0.005
8145.2	60	0.025	0.005
8161.9	60	0.025	0.185
8192.5	60	0.055	-0.145
8203.6	60	0.085	0.065
8209.2	60	0.115	0.005
8212.0	60	0.145	0.005
8216.6	60	0.025	0.005
8233.3	60	0.025	-0.175
8255.6	60	-0.005	0.125
8261.2	60	-0.035	0.005
8266.7	60	-0.065	0.035
8269.5	60	-0.095	0.005
8272.3	60	-0.125	0.005
8277.9	60	0.025	0.005

8294.6	60	0.025	0.185
8322.4	60	0.055	-0.115
8333.5	60	0.085	0.065
8339.1	60	0.115	0.005
8341.9	60	0.145	0.005
8346.5	60	0.025	0.005
8360.4	60	0.025	-0.145
8382.7	60	-0.005	0.125
8388.3	60	-0.035	0.005
8391.1	60	-0.065	0.005
8393.8	60	-0.095	0.005
8398.5	60	0.025	0.005
8415.2	60	0.025	0.185
8440.2	60	0.055	-0.115
8451.4	60	0.085	0.065
8456.9	60	0.115	0.005
8460.6	60	0.025	0.005
8474.6	60	0.025	-0.145
8494.0	60	-0.005	0.095
8499.6	60	-0.035	0.005
8502.4	60	-0.065	0.005
8505.2	60	-0.095	0.005
8509.8	60	0.025	0.005
8523.7	60	0.025	0.155
8548.8	60	0.055	-0.115
8557.1	60	0.085	0.035
8562.7	60	0.115	0.005
8566.4	60	0.025	0.005
8580.3	60	0.025	-0.145
8599.8	60	-0.005	0.095
8605.4	60	-0.035	0.005
8608.2	60	-0.065	0.005
8610.9	60	-0.095	0.005
8615.6	60	0.025	0.005
8629.5	60	0.025	0.155
8654.5	60	0.055	-0.115
8662.9	60	0.085	0.035

8665.7	60	0.115	0.005
8669.4	60	0.025	0.005
8683.3	60	0.025	-0.145
8702.8	60	-0.005	0.095
8708.4	60	-0.035	0.005
8711.1	60	-0.065	0.005
8713.9	60	-0.095	0.005
8718.6	60	0.025	0.005
8732.5	60	0.025	0.155
8752.0	60	0.055	-0.085
8760.3	60	0.085	0.035
8763.1	60	0.115	0.005
8766.8	60	0.025	0.005
8780.7	60	0.025	-0.145
8797.4	60	-0.005	0.095
8800.2	60	-0.035	0.005
8803.0	60	-0.065	0.005
8806.7	60	0.025	0.005
8820.6	60	0.025	0.155
8840.1	60	0.055	-0.085
8848.5	60	0.085	0.035
8851.2	60	0.115	0.005
8854.9	60	0.025	0.005
8866.1	60	0.025	-0.115
8882.8	60	-0.005	0.095
8885.6	60	-0.035	0.005
8888.3	60	-0.065	0.005
8892.1	60	0.025	0.005
8906.0	60	0.025	0.155
8925.5	60	0.055	-0.085
8933.8	60	0.085	0.035
8936.6	60	0.115	0.005
8940.3	60	0.025	0.005
8951.4	60	0.025	-0.115
8968.1	60	-0.005	0.095
8970.9	60	-0.035	0.005
8973.7	60	-0.065	0.005

8977.4	60	0.025	0.005
8988.5	60	0.025	0.125
9008.0	60	0.055	-0.085
9013.6	60	0.085	0.035
9016.4	60	0.115	0.005
9020.1	60	0.025	0.005
9031.2	60	0.025	-0.115
9045.1	60	-0.005	0.065
9047.9	60	-0.035	0.005
9050.7	60	-0.065	0.005
9054.4	60	0.025	0.005
9065.6	60	0.025	0.125
9085.0	60	0.055	-0.085
9090.6	60	0.085	0.035
9093.4	60	0.115	0.005
9097.1	60	0.025	0.005
9108.2	60	0.025	-0.115
9122.1	60	-0.005	0.065
9124.9	60	-0.035	0.005
9127.7	60	-0.065	0.005
9131.4	60	0.025	0.005
9142.6	60	0.025	0.125
9162.0	60	0.055	-0.085
9167.6	60	0.085	0.035
9170.4	60	0.115	0.005
9174.1	60	0.025	0.005
9185.2	60	0.025	-0.115
9199.2	60	-0.005	0.065
9201.9	60	-0.035	0.005
9204.7	60	0.025	0.005
9215.9	60	0.025	0.125
9235.3	60	0.055	-0.085
9240.9	60	0.085	0.035
9243.7	60	0.025	0.005
9254.8	60	0.025	-0.115
9268.7	60	-0.005	0.065
9271.5	60	-0.035	0.005

9274.3	60	0.025	0.005
9282.7	60	0.025	0.095
9299.4	60	0.055	-0.055
9304.9	60	0.085	0.035
9307.7	60	0.025	0.005
9318.8	60	0.025	-0.115
9332.8	60	-0.005	0.065
9335.5	60	-0.035	0.005
9338.3	60	0.025	0.005
9346.7	60	0.025	0.095
9363.4	60	0.055	-0.055
9368.9	60	0.085	0.035
9371.7	60	0.025	0.005
9380.1	60	0.025	-0.085
9394.0	60	-0.005	0.065
9396.8	60	-0.035	0.005
9399.6	60	0.025	0.005
9407.9	60	0.025	0.095
9421.8	60	0.055	-0.055
9427.4	60	0.085	0.035
9430.2	60	0.025	0.005
9438.5	60	0.025	-0.085
9449.7	60	-0.005	0.065
9452.4	60	-0.035	0.005
9455.2	60	0.025	0.005
9463.6	60	0.025	0.095
9477.5	60	0.055	-0.055
9483.1	60	0.085	0.035
9485.8	60	0.025	0.005
9494.2	60	0.025	-0.085
9505.3	60	-0.005	0.065
9508.1	60	-0.035	0.005
9510.9	60	0.025	0.005
9519.2	60	0.025	0.095
9533.2	60	0.055	-0.055
9538.7	60	0.085	0.035
9541.5	60	0.025	0.005

9549.9	60	0.025	-0.085
9561.0	60	-0.005	0.065
9563.8	60	-0.035	0.005
9566.6	60	0.025	0.005
9574.9	60	0.025	0.095
9588.8	60	0.055	-0.055
9594.4	60	0.085	0.035
9597.2	60	0.025	0.005
9605.5	60	0.025	-0.085
9616.7	60	-0.005	0.065
9619.4	60	-0.035	0.005
9622.2	60	0.025	0.005
9630.6	60	0.025	0.095
9644.5	60	0.055	-0.055
9650.1	60	0.085	0.035
9652.8	60	0.025	0.005
9661.2	60	0.025	-0.085
9669.5	60	-0.005	0.035
9672.3	60	-0.035	0.005
9675.1	60	0.025	0.005
9683.5	60	0.025	0.095
9697.4	60	0.055	-0.055
9700.2	60	0.085	0.005
9702.9	60	0.025	0.005
9708.5	60	0.025	-0.055
9716.9	60	-0.005	0.035
9719.6	60	-0.035	0.005
9722.4	60	0.025	0.005
9730.8	60	0.025	0.095
9744.7	60	0.055	-0.055
9747.5	60	0.085	0.005
9750.3	60	0.025	0.005
9755.8	60	0.025	-0.055
9764.2	60	-0.005	0.035
9767.0	60	-0.035	0.005
9769.7	60	0.025	0.005
9778.1	60	0.025	0.095

9792.0	60	0.055	-0.055
9794.8	60	0.085	0.005
9797.6	60	0.025	0.005
9803.1	60	0.025	-0.055
9811.5	60	-0.005	0.035
9814.3	60	-0.035	0.005
9817.1	60	0.025	0.005
9825.4	60	0.025	0.095
9839.3	60	0.055	-0.055
9842.1	60	0.085	0.005
9844.9	60	0.025	0.005
9850.5	60	0.025	-0.055
9858.8	60	-0.005	0.035
9861.6	60	-0.035	0.005
9864.4	60	0.025	0.005
9869.9	60	0.025	0.065
9883.9	60	0.055	-0.055
9886.6	60	0.085	0.005
9889.4	60	0.025	0.005
9895.0	60	0.025	-0.055
9903.3	60	-0.005	0.035
9906.1	60	-0.035	0.005
9908.9	60	0.025	0.005
9914.5	60	0.025	0.065
9925.6	60	0.055	-0.025
9928.4	60	0.085	0.005
9931.2	60	0.025	0.005
9936.7	60	0.025	-0.055
9945.1	60	-0.005	0.035
9947.9	60	-0.035	0.005
9950.7	60	0.025	0.005
9956.2	60	0.025	0.065
9967.4	60	0.055	-0.025
9970.1	60	0.085	0.005
9972.9	60	0.025	0.005
9978.5	60	0.025	-0.055
9986.8	60	-0.005	0.035

9989.6	60	-0.035	0.005
9992.4	60	0.025	0.005
9998.0	60	0.025	0.065
10009.1	60	0.055	-0.025
10011.9	60	0.085	0.005
10014.7	60	0.025	0.005
10020.2	60	0.025	-0.055
10028.6	60	-0.005	0.035
10030.4	60	0.025	0.005
10036.0	60	0.025	0.065
10047.1	60	0.055	-0.025
10049.9	60	0.085	0.005
10052.7	60	0.025	0.005
10058.3	60	0.025	-0.055
10066.6	60	-0.005	0.035
10068.5	60	0.025	0.005
10074.1	60	0.025	0.065
10085.2	60	0.055	-0.025
10088.0	60	0.085	0.005
10090.8	60	0.025	0.005
10096.3	60	0.025	-0.055
10104.7	60	-0.005	0.035
10106.5	60	0.025	0.005
10112.1	60	0.025	0.065
10123.2	60	0.055	-0.025
10126.0	60	0.085	0.005
10128.8	60	0.025	0.005
10134.4	60	0.025	-0.055
10142.7	60	-0.005	0.035
10144.6	60	0.025	0.005
10150.1	60	0.025	0.065
10161.3	60	0.055	-0.025
10164.0	60	0.085	0.005
10166.8	60	0.025	0.005
10172.4	60	0.025	-0.055
10180.7	60	-0.005	0.035
10182.6	60	0.025	0.005

10188.2	60	0.025	0.065
10196.5	60	0.055	-0.025
10199.3	60	0.085	0.005
10202.1	60	0.025	0.005
10207.7	60	0.025	-0.055
10216.0	60	-0.005	0.035
10217.9	60	0.025	0.005
10223.4	60	0.025	0.065
10231.8	60	0.055	-0.025
10234.6	60	0.085	0.005
10237.3	60	0.025	0.005
10242.9	60	0.025	-0.055
10251.3	60	-0.005	0.035
10253.1	60	0.025	0.005
10258.7	60	0.025	0.065
10267.0	60	0.055	-0.025
10269.8	60	0.085	0.005
10272.6	60	0.025	0.005
10278.2	60	0.025	-0.055
10286.5	60	-0.005	0.035
10288.4	60	0.025	0.005
10293.9	60	0.025	0.065
10302.3	60	0.055	-0.025
10305.1	60	0.085	0.005
10307.9	60	0.025	0.005
10313.4	60	0.025	-0.055
10321.8	60	-0.005	0.035
10323.6	60	0.025	0.005
10329.2	60	0.025	0.065
10337.5	60	0.055	-0.025
10340.3	60	0.085	0.005
10343.1	60	0.025	0.005
10348.7	60	0.025	-0.055
10357.0	60	-0.005	0.035
10358.9	60	0.025	0.005
10364.4	60	0.025	0.065
10372.8	60	0.055	-0.025

10375.6	60	0.085	0.005
10378.4	60	0.025	0.005
10383.9	60	0.025	-0.055
10392.3	60	-0.005	0.035
10394.1	60	0.025	0.005
10399.7	60	0.025	0.065
10408.1	60	0.055	-0.025
10410.8	60	0.085	0.005
10413.6	60	0.025	0.005
10419.2	60	0.025	-0.055
10427.5	60	-0.005	0.035
10429.4	60	0.025	0.005
10435.0	60	0.025	0.065
10443.3	60	0.055	-0.025
10446.1	60	0.085	0.005
10448.9	60	0.025	0.005
10454.4	60	0.025	-0.055
10462.8	60	-0.005	0.035
10464.6	60	0.025	0.005
10470.2	60	0.025	0.065
10478.6	60	0.055	-0.025
10481.3	60	0.085	0.005
10484.1	60	0.025	0.005
10489.7	60	0.025	-0.055
10498.0	60	-0.005	0.035
10499.9	60	0.025	0.005
10505.5	60	0.025	0.065
10513.8	60	0.055	-0.025
10516.6	60	0.085	0.005
10519.4	60	0.025	0.005
10525.0	60	0.025	-0.055
10533.3	60	-0.005	0.035
10535.2	60	0.025	0.005
10540.7	60	0.025	0.065
10549.1	60	0.055	-0.025
10551.9	60	0.085	0.005
10554.6	60	0.025	0.005

10560.2	60	0.025	-0.055
10568.6	60	-0.005	0.035
10570.4	60	0.025	0.005
10576.0	60	0.025	0.065
10584.3	60	0.055	-0.025
10586.2	60	0.025	0.005
10589.0	60	0.025	-0.025
10597.3	60	-0.005	0.035
10599.2	60	0.025	0.005
10604.7	60	0.025	0.065
10613.1	60	0.055	-0.025
10615.0	60	0.025	0.005
10617.7	60	0.025	-0.025
10626.1	60	-0.005	0.035
10627.9	60	0.025	0.005
10633.5	60	0.025	0.065
10641.9	60	0.055	-0.025
10643.7	60	0.025	0.005
10646.5	60	0.025	-0.025
10654.8	60	-0.005	0.035
10656.7	60	0.025	0.005
10662.3	60	0.025	0.065
10670.6	60	0.055	-0.025
10672.5	60	0.025	0.005
10675.3	60	0.025	-0.025
10683.6	60	-0.005	0.035
10685.5	60	0.025	0.005
10691.0	60	0.025	0.065
10699.4	60	0.055	-0.025
10701.2	60	0.025	0.005
10704.0	60	0.025	-0.025
10712.4	60	-0.005	0.035
10714.2	60	0.025	0.005
10719.8	60	0.025	0.065
10728.1	60	0.055	-0.025
10730.0	60	0.025	0.005
10732.8	60	0.025	-0.025



10741.1	60	-0.005	0.035
10743.0	60	0.025	0.005
10748.6	60	0.025	0.065
10756.9	60	0.055	-0.025
10758.8	60	0.025	0.005
10761.5	60	0.025	-0.025
10769.9	60	-0.005	0.035
10771.7	60	0.025	0.005
10777.3	60	0.025	0.065
10785.7	60	0.055	-0.025
10787.5	60	0.025	0.005
10790.3	60	0.025	-0.025
10798.7	60	-0.005	0.035
10800.5	60	0.025	0.005
10806.1	60	0.025	0.065
10814.4	60	0.055	-0.025
10816.3	60	0.025	0.005
10819.1	60	0.025	-0.025
10827.4	60	-0.005	0.035
10829.3	60	0.025	0.005
10834.8	60	0.025	0.065
10843.2	60	0.055	-0.025
10845.0	60	0.025	0.005
10847.8	60	0.025	-0.025
10856.2	60	-0.005	0.035
10858.0	60	0.025	0.005
10863.6	60	0.025	0.065
10871.9	60	0.055	-0.025
10873.8	60	0.025	0.005
10876.6	60	0.025	-0.025
10884.9	60	-0.005	0.035
10886.8	60	0.025	0.005
10889.6	60	0.025	0.035
10897.9	60	0.055	-0.025
10899.8	60	0.025	0.005
10902.6	60	0.025	-0.025
10908.1	60	-0.005	0.035

10910.0	60	0.025	0.005
10912.8	60	0.025	0.035
10921.1	60	0.055	-0.025
10923.0	60	0.025	0.005
10925.8	60	0.025	-0.025
10931.3	60	-0.005	0.035
10933.2	60	0.025	0.005
10936.0	60	0.025	0.035
10944.3	60	0.055	-0.025
10946.2	60	0.025	0.005
10949.0	60	0.025	-0.025
10954.5	60	-0.005	0.035
10956.4	60	0.025	0.005
10959.2	60	0.025	0.035
10967.5	60	0.055	-0.025
10969.4	60	0.025	0.005
10972.1	60	0.025	-0.025
10977.7	60	-0.005	0.035
10979.6	60	0.025	0.005
10982.4	60	0.025	0.035
10990.7	60	0.055	-0.025
10992.6	60	0.025	0.005
10995.3	60	0.025	-0.025
11000.9	60	-0.005	0.035
11002.8	60	0.025	0.005
11005.5	60	0.025	0.035
11013.9	60	0.055	-0.025
11015.8	60	0.025	0.005
11018.5	60	0.025	-0.025
11024.1	60	-0.005	0.035
11026.0	60	0.025	0.005
11028.7	60	0.025	0.035
11037.1	60	0.055	-0.025
11038.9	60	0.025	0.005
11041.7	60	0.025	-0.025
11047.3	60	-0.005	0.035
11049.2	60	0.025	0.005

11051.9	60	0.025	0.035
11057.5	60	0.055	0.005
11059.4	60	0.025	0.005
11062.1	60	0.025	-0.025
11067.7	60	-0.005	0.035
11069.6	60	0.025	0.005
11072.3	60	0.025	0.035
11077.9	60	0.055	0.005
11079.8	60	0.025	0.005
11082.6	60	0.025	-0.025
11088.1	60	-0.005	0.035
11090.0	60	0.025	0.005
11092.8	60	0.025	0.035
11098.3	60	0.055	0.005
11100.2	60	0.025	0.005
11103.0	60	0.025	-0.025
11108.5	60	-0.005	0.035
11110.4	60	0.025	0.005
11113.2	60	0.025	0.035
11118.7	60	0.055	0.005
11120.6	60	0.025	0.005
11123.4	60	0.025	-0.025
11128.9	60	-0.005	0.035
11130.8	60	0.025	0.005
11133.6	60	0.025	0.035
11139.1	60	0.055	0.005
11141.0	60	0.025	0.005
11143.8	60	0.025	-0.025
11149.4	60	-0.005	0.035
11151.2	60	0.025	0.005
11154.0	60	0.025	0.035
11159.6	60	0.055	0.005
11161.4	60	0.025	0.005
11164.2	60	0.025	-0.025
11169.8	60	-0.005	0.035
11171.6	60	0.025	0.005
11174.4	60	0.025	0.035

11180.0	60	0.055	0.005
11181.8	60	0.025	0.005
11184.6	60	0.025	-0.025
11187.4	60	-0.005	0.005
11189.2	60	0.025	0.005
11192.0	60	0.025	0.035
11197.6	60	0.055	0.005
11199.5	60	0.025	0.005
11202.2	60	0.025	-0.025
11205.0	60	-0.005	0.005
11206.9	60	0.025	0.005
11209.7	60	0.025	0.035
11215.2	60	0.055	0.005
11217.1	60	0.025	0.005
11219.9	60	0.025	-0.025
11222.6	60	-0.005	0.005
11224.5	60	0.025	0.005
11227.3	60	0.025	0.035
11232.9	60	0.055	0.005
11234.7	60	0.025	0.005
11237.5	60	0.025	-0.025
11240.3	60	-0.005	0.005
11242.1	60	0.025	0.005
11244.9	60	0.025	0.035
11250.5	60	0.055	0.005
11252.3	60	0.025	0.005
11255.1	60	0.025	-0.025
11257.9	60	-0.005	0.005
11259.8	60	0.025	0.005
11262.5	60	0.025	0.035
11268.1	60	0.055	0.005
11270.0	60	0.025	0.005
11272.7	60	0.025	-0.025
11275.5	60	-0.005	0.005
11277.4	60	0.025	0.005
11280.2	60	0.025	0.035
11285.7	60	0.055	0.005

11287.6	60	0.025	0.005
11290.4	60	0.025	-0.025
11293.2	60	-0.005	0.005
11295.0	60	0.025	0.005
11297.8	60	0.025	0.035
11303.4	60	0.055	0.005
11305.2	60	0.025	0.005
11308.0	60	0.025	-0.025
11310.8	60	-0.005	0.005
11312.6	60	0.025	0.005
11315.4	60	0.025	0.035
11321.0	60	0.055	0.005
11322.8	60	0.025	0.005
11325.6	60	0.025	-0.025
11328.4	60	-0.005	0.005
11330.3	60	0.025	0.005
11333.1	60	0.025	0.035
11338.6	60	0.055	0.005
11340.5	60	0.025	0.005
11343.3	60	0.025	-0.025
11346.0	60	-0.005	0.005
11347.9	60	0.025	0.005
11350.7	60	0.025	0.035
11356.2	60	0.055	0.005
11358.1	60	0.025	0.005
11360.9	60	0.025	-0.025
11363.7	60	-0.005	0.005
11365.5	60	0.025	0.005
11368.3	60	0.025	0.035
11371.1	60	0.055	0.005
11372.9	60	0.025	0.005
11375.7	60	0.025	-0.025
11378.5	60	-0.005	0.005
11380.4	60	0.025	0.005
11383.2	60	0.025	0.035
11385.9	60	0.055	0.005
11387.8	60	0.025	0.005

11390.6	60	0.025	-0.025
11393.4	60	-0.005	0.005
11395.2	60	0.025	0.005
11398.0	60	0.025	0.035
11400.8	60	0.055	0.005
11402.6	60	0.025	0.005
11405.4	60	0.025	-0.025
11408.2	60	-0.005	0.005
11410.1	60	0.025	0.005
11412.8	60	0.025	0.035
11415.6	60	0.055	0.005
11417.5	60	0.025	0.005
11420.3	60	0.025	-0.025
11423.0	60	-0.005	0.005
11424.9	60	0.025	0.005
11427.7	60	0.025	0.035
11430.5	60	0.055	0.005
11432.3	60	0.025	0.005
11435.1	60	0.025	-0.025
11437.9	60	-0.005	0.005
11439.7	60	0.025	0.005
11442.5	60	0.025	0.035
11445.3	60	0.055	0.005
11447.2	60	0.025	0.005
11450.0	60	0.025	-0.025
11452.7	60	-0.005	0.005
11454.6	60	0.025	0.005
11457.4	60	0.025	0.035
11460.2	60	0.055	0.005
11462.0	60	0.025	0.005
11464.8	60	0.025	-0.025
11467.6	60	-0.005	0.005
11469.4	60	0.025	0.005
11472.2	60	0.025	0.035
11475.0	60	0.055	0.005
11476.9	60	0.025	0.005
11479.6	60	0.025	-0.025

11482.4	60	-0.005	0.005
11484.3	60	0.025	0.005
11487.1	60	0.025	0.035
11489.8	60	0.055	0.005
11491.7	60	0.025	0.005
11494.5	60	0.025	-0.025
11497.3	60	-0.005	0.005
11499.1	60	0.025	0.005
11501.9	60	0.025	0.035
11504.7	60	0.055	0.005
11506.6	60	0.025	0.005
11509.3	60	0.025	-0.025
11512.1	60	-0.005	0.005
11514.0	60	0.025	0.005
11516.8	60	0.025	0.035
11519.5	60	0.055	0.005
11521.4	60	0.025	0.005
11524.2	60	0.025	-0.025
11527.0	60	-0.005	0.005
11528.8	60	0.025	0.005
11531.6	60	0.025	0.035
11534.4	60	0.055	0.005
11536.2	60	0.025	0.005
11539.0	60	0.025	-0.025
11541.8	60	-0.005	0.005
11543.7	60	0.025	0.005
11546.4	60	0.025	0.035
11549.2	60	0.055	0.005
11551.1	60	0.025	0.005
11553.9	60	0.025	-0.025
11556.7	60	-0.005	0.005
11558.5	60	0.025	0.005
11561.3	60	0.025	0.035
11564.1	60	0.055	0.005
11565.9	60	0.025	0.005
11568.7	60	0.025	-0.025
11571.5	60	-0.005	0.005

11573.4	60	0.025	0.005
11576.1	60	0.025	0.035
11578.9	60	0.055	0.005
11580.8	60	0.025	0.005
11583.6	60	0.025	-0.025
11586.3	60	-0.005	0.005
11588.2	60	0.025	0.005
11591.0	60	0.025	0.035
11593.8	60	0.055	0.005
11595.6	60	0.025	0.005
11598.4	60	0.025	-0.025
11601.2	60	-0.005	0.005
11603.0	60	0.025	0.005
11605.8	60	0.025	0.035
11608.6	60	0.055	0.005
11610.5	60	0.025	0.005
11613.2	60	0.025	-0.025
11616.0	60	-0.005	0.005
11617.9	60	0.025	0.005
11620.7	60	0.025	0.035
11623.5	60	0.055	0.005
11625.3	60	0.025	0.005
11628.1	60	0.025	-0.025
11630.9	60	-0.005	0.005
11632.7	60	0.025	0.005
11635.5	60	0.025	0.035
11638.3	60	0.055	0.005
11640.2	60	0.025	0.005
11642.9	60	0.025	-0.025
11645.7	60	-0.005	0.005
11647.6	60	0.025	0.005
11650.4	60	0.025	0.035
11653.1	60	0.055	0.005
11655.0	60	0.025	0.005
11657.8	60	0.025	-0.025
11660.6	60	-0.005	0.005
11662.4	60	0.025	0.005

11665.2	60	0.025	0.035
11668.0	60	0.055	0.005
11669.8	60	0.025	0.005
11672.6	60	0.025	-0.025
11675.4	60	-0.005	0.005
11677.3	60	0.025	0.005
11680.0	60	0.025	0.035
11682.8	60	0.055	0.005
11684.7	60	0.025	0.005
11687.5	60	0.025	-0.025
11690.3	60	-0.005	0.005
11692.1	60	0.025	0.005
11694.9	60	0.025	0.035
11697.7	60	0.055	0.005
11699.5	60	0.025	0.005
11702.3	60	0.025	-0.025
11705.1	60	-0.005	0.005
11707.0	60	0.025	0.005
11709.7	60	0.025	0.035
11712.5	60	0.055	0.005
11714.4	60	0.025	0.005
11717.2	60	0.025	-0.025
11719.9	60	-0.005	0.005
11721.8	60	0.025	0.005
11724.6	60	0.025	0.035
11727.4	60	0.055	0.005
11729.2	60	0.025	0.005
11732.0	60	0.025	-0.025
11734.8	60	-0.005	0.005
11736.6	60	0.025	0.005
11739.4	60	0.025	0.035
11742.2	60	0.055	0.005
11744.1	60	0.025	0.005
11746.8	60	0.025	-0.025
11749.6	60	-0.005	0.005
11751.5	60	0.025	0.005
11754.3	60	0.025	0.035

11757.1	60	0.055	0.005
11758.9	60	0.025	0.005
11761.7	60	0.025	-0.025
11764.5	60	-0.005	0.005
11766.3	60	0.025	0.005
11769.1	60	0.025	0.035
11771.9	60	0.055	0.005
11773.8	60	0.025	0.005
11776.5	60	0.025	-0.025
11779.3	60	-0.005	0.005
11781.2	60	0.025	0.005
11784.0	60	0.025	0.035
11786.7	60	0.055	0.005
11788.6	60	0.025	0.005
11791.4	60	0.025	-0.025
11794.2	60	-0.005	0.005
11796.0	60	0.025	0.005
11798.8	60	0.025	0.035
11801.6	60	0.055	0.005
11803.4	60	0.025	0.005
11806.2	60	0.025	-0.025
11809.0	60	-0.005	0.005
11810.9	60	0.025	0.005
11813.6	60	0.025	0.035
11816.4	60	0.055	0.005
11818.3	60	0.025	0.005
11821.1	60	0.025	-0.025
11823.9	60	-0.005	0.005
11825.7	60	0.025	0.005
11828.5	60	0.025	0.035
11831.3	60	0.055	0.005
11833.1	60	0.025	0.005
11835.9	60	0.025	-0.025
11838.7	60	-0.005	0.005
11840.6	60	0.025	0.005
11843.3	60	0.025	0.035
11846.1	60	0.055	0.005

11848.0	60	0.025	0.005
11850.8	60	0.025	-0.025
11853.5	60	-0.005	0.005
11855.4	60	0.025	0.005
11858.2	60	0.025	0.035
11861.0	60	0.055	0.005
11862.8	60	0.025	0.005
11865.6	60	0.025	-0.025
11868.4	60	-0.005	0.005
11870.2	60	0.025	0.005
11873.0	60	0.025	0.035
11875.8	60	0.055	0.005
11877.7	60	0.025	0.005
11883.2	60	0.025	0.005
11886.0	60	-0.005	0.005
11887.9	60	0.025	0.005
11890.7	60	0.025	0.035
11893.4	60	0.055	0.005
11895.3	60	0.025	0.005
11900.9	60	0.025	0.005
11903.6	60	-0.005	0.005
11905.5	60	0.025	0.005
11908.3	60	0.025	0.035
11911.1	60	0.055	0.005
11912.9	60	0.025	0.005
11918.5	60	0.025	0.005
11921.3	60	-0.005	0.005
11923.1	60	0.025	0.005
11925.9	60	0.025	0.035
11928.7	60	0.055	0.005
11930.5	60	0.025	0.005
11936.1	60	0.025	0.005
11938.9	60	-0.005	0.005
11940.8	60	0.025	0.005
11943.5	60	0.025	0.035
11946.3	60	0.055	0.005
11948.2	60	0.025	0.005

11953.7	60	0.025	0.005
11956.5	60	-0.005	0.005
11958.4	60	0.025	0.005
11961.2	60	0.025	0.035
11963.9	60	0.055	0.005
11965.8	60	0.025	0.005
11971.4	60	0.025	0.005
11974.2	60	-0.005	0.005
11976.0	60	0.025	0.005
11978.8	60	0.025	0.035
11981.6	60	0.055	0.005
11983.4	60	0.025	0.005
11989.0	60	0.025	0.005
11991.8	60	-0.005	0.005
11993.6	60	0.025	0.005
11996.4	60	0.025	0.035
11999.2	60	0.055	0.005
12001.1	60	0.025	0.005
12006.6	60	0.025	0.005
12009.4	60	-0.005	0.005
12011.3	60	0.025	0.005
12014.0	60	0.025	0.035
12016.8	60	0.055	0.005
12018.7	60	0.025	0.005
12024.3	60	0.025	0.005
12027.0	60	-0.005	0.005
12028.9	60	0.025	0.005
12031.7	60	0.025	0.035
12034.5	60	0.055	0.005
12036.3	60	0.025	0.005
12041.9	60	0.025	0.005
12044.7	60	-0.005	0.005
12046.5	60	0.025	0.005
12049.3	60	0.025	0.035
12052.1	60	0.055	0.005
12053.9	60	0.025	0.005
12059.5	60	0.025	0.005

12062.3	60	-0.005	0.005
12064.1	60	0.025	0.005
12066.9	60	0.025	0.035
12069.7	60	0.055	0.005
12071.6	60	0.025	0.005
12077.1	60	0.025	0.005
12079.9	60	-0.005	0.005
12081.8	60	0.025	0.005
12084.6	60	0.025	0.035
12087.3	60	0.055	0.005
12089.2	60	0.025	0.005
12094.8	60	0.025	0.005
12097.5	60	-0.005	0.005
12099.4	60	0.025	0.005
12102.2	60	0.025	0.035
12105.0	60	0.055	0.005
12106.8	60	0.025	0.005
12112.4	60	0.025	0.005
12115.2	60	-0.005	0.005
12117.0	60	0.025	0.005
12119.8	60	0.025	0.035
12122.6	60	0.055	0.005
12124.5	60	0.025	0.005
12130.0	60	0.025	0.005
12132.8	60	-0.005	0.005
12134.7	60	0.025	0.005
12137.4	60	0.025	0.035
12140.2	60	0.055	0.005
12142.1	60	0.025	0.005
12147.6	60	0.025	0.005
12150.4	60	-0.005	0.005
12152.3	60	0.025	0.005
12155.1	60	0.025	0.035
12157.9	60	0.055	0.005
12159.7	60	0.025	0.005
12165.3	60	0.025	0.005
12168.1	60	-0.005	0.005

12169.9	60	0.025	0.005
12172.7	60	0.025	0.035
12175.5	60	0.055	0.005
12177.3	60	0.025	0.005
12182.9	60	0.025	0.005
12185.7	60	-0.005	0.005
12187.5	60	0.025	0.005
12190.3	60	0.025	0.035
12193.1	60	0.055	0.005
12195.0	60	0.025	0.005
12200.5	60	0.025	0.005
12203.3	60	-0.005	0.005
12205.2	60	0.025	0.005
12208.0	60	0.025	0.035
12210.7	60	0.055	0.005
12212.6	60	0.025	0.005
12218.2	60	0.025	0.005
12220.9	60	-0.005	0.005
12222.8	60	0.025	0.005
12225.6	60	0.025	0.035
12228.4	60	0.055	0.005
12230.2	60	0.025	0.005
12235.8	60	0.025	0.005
12238.6	60	-0.005	0.005
12240.4	60	0.025	0.005
12243.2	60	0.025	0.035
12246.0	60	0.055	0.005
12247.8	60	0.025	0.005
12253.4	60	0.025	0.005
12256.2	60	-0.005	0.005
12258.1	60	0.025	0.005
12260.8	60	0.025	0.035
12263.6	60	0.055	0.005
12265.5	60	0.025	0.005
12271.0	60	0.025	0.005
12273.8	60	-0.005	0.005
12275.7	60	0.025	0.005

12278.5	60	0.025	0.035
12281.2	60	0.055	0.005
12283.1	60	0.025	0.005
12288.7	60	0.025	0.005
12291.5	60	-0.005	0.005
12293.3	60	0.025	0.005
12296.1	60	0.025	0.035
12298.9	60	0.055	0.005
12300.7	60	0.025	0.005
12306.3	60	0.025	0.005
12309.1	60	-0.005	0.005
12310.9	60	0.025	0.005
12313.7	60	0.025	0.035
12316.5	60	0.055	0.005
12318.4	60	0.025	0.005
12323.9	60	0.025	0.005
12326.7	60	-0.005	0.005
12328.6	60	0.025	0.005
12331.3	60	0.025	0.035
12334.1	60	0.055	0.005
12336.0	60	0.025	0.005
12341.6	60	0.025	0.005
12344.3	60	-0.005	0.005
12346.2	60	0.025	0.005
12349.0	60	0.025	0.035
12351.8	60	0.055	0.005
12353.6	60	0.025	0.005
12359.2	60	0.025	0.005
12362.0	60	-0.005	0.005
12363.8	60	0.025	0.005
12366.6	60	0.025	0.035
12369.4	60	0.055	0.005
12371.2	60	0.025	0.005
12376.8	60	0.025	0.005
12379.6	60	-0.005	0.005
12381.4	60	0.025	0.005
12384.2	60	0.025	0.035

12387.0	60	0.055	0.005
12388.9	60	0.025	0.005
12394.4	60	0.025	0.005
12397.2	60	-0.005	0.005
12399.1	60	0.025	0.005
12401.9	60	0.025	0.035
12404.6	60	0.055	0.005
12406.5	60	0.025	0.005
12412.1	60	0.025	0.005
12414.8	60	-0.005	0.005
12416.7	60	0.025	0.005
12419.5	60	0.025	0.035
12422.3	60	0.055	0.005
12424.1	60	0.025	0.005
12429.7	60	0.025	0.005
12432.5	60	-0.005	0.005
12434.3	60	0.025	0.005
12437.1	60	0.025	0.035
12439.9	60	0.055	0.005
12441.8	60	0.025	0.005
12447.3	60	0.025	0.005
12450.1	60	-0.005	0.005
12452.0	60	0.025	0.005
12454.7	60	0.025	0.035
12457.5	60	0.055	0.005
12459.4	60	0.025	0.005
12464.9	60	0.025	0.005
12467.7	60	-0.005	0.005
12469.6	60	0.025	0.005
12475.2	60	0.025	0.005
12477.9	60	0.055	0.005
12479.8	60	0.025	0.005
12485.4	60	0.025	0.005
12488.1	60	-0.005	0.005
12490.0	60	0.025	0.005



## Annex 10 – Appendix 4

### Test equipment tolerances

**Table B.1**

Instrumentation accuracy

<i>Parameter</i>	<i>Control accuracy</i>	<i>Instrumentation accuracy at full scale</i>
Tyre forces	Fz: $\pm 50$ N or 1% using filtered values whichever is greater. Fy: $\pm 100$ N or 5% using filtered values whichever is greater, for the difference between input peaks and actually generated peaks. Fx: $\pm 100$ N or 5% using filtered values whichever is greater, for the difference between input peaks and actually generated peaks. My: $\pm 40$ Nm or 5% using filtered values whichever is greater, for the difference between input peaks and actually generated peaks.	Fz: $\pm 1\%$ Fy: $\pm 1\%$ Fx: $\pm 1\%$ My: $\pm 1\%$
Inflation pressure	$\pm 3$ kPa	$\pm 3$ kPa
Mass scale	not applicable	$\pm 2$ g
Test duration	For the test time durations, the total time of an actual test shall not differ more than $\pm 5\%$ from the total input time, 68.83h (247800s). The interval of measurement shall be more than 1Hz.	$\pm 0.02$ s for the time increments
Camber angle	0 $\pm 0.1$ degrees	0 $\pm 0.1$ degrees
Thermometer	$\pm 5$ °C	$\pm 0.5$ °C
Speed	$\pm 2$ km/h	$\pm 0.1\%$

## **Annex 10 – Appendix 5**

### **Replacement of sandpaper surface**

Sandpaper surface shall be replaced when it does not meet the specifications described in 2.3.2.3.;

Sandpaper surface should be replaced either when:

Running distance reached 20000 km for 2 positions drum in case of 3 m, 40000 km for 1 position drum in case of 3 m,

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 Drum diameter owned by each testing institution (m) / Standard drum diameter (m)

Where:

Road surface replacement distance (standard value) = 20000 km;

Standard drum diameter = 3 m.

## Annex 10 – Appendix 6

### Example of a test report for indoor drum test method

The test report shall include the following information.

Test report number:	
Test machine identification:	
Drum circumference (m),	
Test cycle (2 positions /1 position)	
	Talc or Silica

Test date:	~
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	Beginning of test	End of test
MPD of test surface (mm):		
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)			
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			

"