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Passenger car, commercial vehicle, truck and bus tyres — Methods for measuring snow grip performance — Loaded new tyres

Pneumatiques pour voitures particulière, véhicules utilitaires, camions et autobus — Méthodes de mesurage de l´adhérence sur neige — Pneumatiques neufs en charge

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 31, *Tyres, rims and valves*.

Passenger car, commercial vehicle, truck and bus tyres — Methods for measuring snow grip performance — Loaded new tyres

1 Scope

This International Standard specifies the method for measuring relative snow grip performance index of a candidate tyre compared to a reference, under loaded conditions for new tyres intended to be used on passenger car, commercial vehicle, truck and bus vehicles on a snow packed surface.

The methods developed here are meant to reduce the variability of the performance measurement. The use of the proper reference tyres is necessary to limit the variability of the testing method procedures.

This International Standard applies to all passenger car, commercial vehicle, truck and bus tyres.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4000-1, *Passenger car tyres and rims (metric series) — Part 1: Tyres*

ISO 4209-1, *Truck and bus tyres and rims (metric series) — Part 1: Tyres*

ASTM F1805, *Standard Test Method for Single Wheel Driving Traction in a Straight Line on Snow- and Ice-Covered Surfaces*

ASTM E1136, *Standard Specification for P195/75R14 Radial Standard Reference Test Tire*

ASTM F2870, *Standard Specification for 315/70R22.5 154/150L Radial Truck Standard Reference Test Tire*

ASTM F2871, *Standard Specification for 245/70R19.5 136/134M Radial Truck Standard Reference Test Tire*

ASTM F2872, *Standard Specification for 225/75R16C 116/114S M+S Radial Light Truck Standard Reference Test Tire*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
passenger car tyre
tyres conforming to ISO 4000-1

3.2
commercial vehicle tyre
tyres conforming to ISO 4209-1 and identified by a load index in single configuration lower or equal to 121 and a speed symbol higher or equal to “N”

3.3
truck and bus tyre
tyres conforming to ISO 4209-1 and identified by

a) a load index in single configuration higher or equal to 122, or

b) a load index in single configuration lower or equal to 121 and a speed symbol lower or equal to “M”

3.4
test run
single pass of a loaded tyre over a given test surface

3.5
tyre set
group of two or four same tyres

3.6
candidate tyre
T
test *tyre set* (3.5) that is part of an evaluation program

3.7
reference tyre
R
special test *tyre set* (3.5), also known as a Standard Reference Test Tyre (SRTT), that is used as a benchmark in an evaluation program

Note 1 to entry: In order to minimize their variation, these tyres have carefully controlled design features and for this reason, they are produced, controlled and stored in accordance with the following ASTM (ASTM International) standards:

— ASTM E1136, SRTT P195/75R14;

— ASTM F2870, SRTT 315/70 R 22.5 - 154/150 L;

— ASTM F2871, SRTT 245/70 R 19.5 - 136/134 M;

— ASTM F2872, SRTT 225/75 R 16 C - 116/114 S.

3.8
control tyre
C
tyre set (3.5) that is part of an evaluation program

Note 1 to entry: It is an intermediate set of tyres which is used when the candidate tyre and the reference tyre cannot be directly compared on the same vehicle.

3.9
braking test
series of a specified number of ABS-braking *test runs* (3.4) of the same tyre repeated within a short time frame

3.10
mean fully developed deceleration
mfdd
average deceleration calculated on the basis of the measured distance recorded when decelerating a vehicle between two specified speeds

3.11
acceleration test
series of a specified number of traction controlled acceleration *test runs* (3.4) of the same tyre repeated within a short time frame

3.12
acceleration force of a tyre
longitudinal force resulting from acceleration torque application

Note 1 to entry: It is expressed in newtons, N.

3.13
acceleration force coefficient of a tyre
AFC
ratio of acceleration force to vertical load

3.14
average acceleration
AA
average acceleration calculated on the basis of the measured distance recorded when accelerating a vehicle between two specified speeds

3.15
Snow Grip Index
SG
ratio between the performance of the candidate tyre to the performance of the proper standard reference test tyre

3.16
loaded radius
distance from wheel axis of rotation to supporting surface (ground) at a given load and stated inflation pressure

4 Test methods

4.1 Braking on snow method for passenger car tyres

4.1.1 General

Snow performance is based on a test method by which the mean fully developed deceleration in a braking test, of a candidate tyre is compared to that of a standard reference test tyre.

The relative performance shall be indicated by a Snow Grip Index (SG).

4.1.2 Test course

The braking tests shall be done on a flat test surface of sufficient length and width, with a maximum 2 % gradient, covered with packed snow.

The snow surface shall be composed of a hard packed snow base at least 3 cm thick and a surface layer of medium packed and prepared snow about 2 cm thick.

The air temperature, measured about one meter above the ground, shall be between −2 °C and −15 °C; the snow temperature, measured at a depth of about one centimetre, shall be between −4 °C and −15 °C.

It is recommended to avoid direct sunlight, large variations of sunlight or humidity, as well as wind.

The snow compaction index measured according to ASTM F1805 by using a CTI penetrometer shall be between 75 and 85.

The candidate tyre should be tested in the same slope and snow compaction condition as the reference tyre to avoid any advantage or disadvantage for the candidate tyre.

4.1.3 Vehicle

The test shall be conducted with a standard production vehicle in good running order and equipped with ABS.

The vehicle used shall be such that the loads on each wheel are appropriate to the tyres being tested. Several different tyre set can be tested on the same vehicle.

4.1.4 Standard reference test tyre

The proper reference tyre to be used to evaluate passenger car tyre snow grip performance is ASTM E1136, SRTT P195/75R14.

4.1.5 Tyres preparation

Fit the test tyres on rims as per ISO 4000-1 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.

The tyres should be prepared prior to testing to remove spew, compound nodules or flashes resulting from the moulding process. The tyre surface in contact with snow shall be clean before performing a test.

Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests. Tyre pressures shall then be adjusted to the values specified for the test.

In case a vehicle cannot accommodate both the reference and candidate tyres, a third tyre ("control" tyre) may be used as an intermediate. First, test the control tyre against the reference on a suitable vehicle, then test the candidate tyre against the control on the other vehicle.

4.1.6 Tyre load

The vehicle load shall be such that the resulting loads on the tyres are between 60 % and 90 % of the load corresponding to the tyre load index.

4.1.7 Tyre inflation pressure

The cold inflation pressure shall be 240 kPa.

4.1.8 Instrumentation

The vehicle shall be fitted with calibrated sensors suitable for measurements in winter conditions. There shall be a data acquisition system to store measurements.

The accuracy of measurement sensors and systems shall be such that the relative uncertainty of the measured or computed mean fully developed decelerations is less than 1 %.

4.1.9 Testing order and sequences

For every candidate tyre and the standard reference test tyre, ABS-braking test runs shall be repeated a minimum of six times.

The zones where ABS-braking is fully applied shall not overlap.

When a new set of tyres is tested, the runs are performed after shifting aside the vehicle trajectory in order not to brake on the tracks of the previous tyre.

When it is no longer possible not to overlap full ABS-braking zones, the test course shall be re-groomed.

Order of testing:

— If only one candidate tyre has to be evaluated, the order of testing shall be as follows:

R1 - T - R2

where

R1 is the initial test of the SRTT;

R2 is the repeat test of the SRTT;

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

— A maximum of two candidate tyres (T1 and T2) may be tested before repeating the SRTT test, for example:

R1 - T1 - T2 - R2

Required sequence is as follows:

— six SRTT repetitions, then shift aside to test next tyre on fresh surface;

— six Candidate one repetitions, then shift aside;

— six Candidate two repetitions, then shift aside;

— six SRTT repetitions, then shift aside.

The comparative tests of SRTT and candidate tyres shall be repeated on two different days.

4.1.10 Test procedure

Drive the vehicle at a speed not lower than 28 km/h.

When the measuring zone has been reached, the vehicle gear is set into neutral, the brake pedal is depressed sharply by a constant force sufficient to cause operation of the ABS on all wheels of the vehicle and to result in stable deceleration of the vehicle and held down until the speed is lower than 8 km/h.

The mean fully developed deceleration between 25 km/h and 10 km/h shall be computed from distance, speed, or deceleration measurements.

The mean fully developed deceleration, mfdd, is given by Formula (1):

$$\text{mfdd} = \left| \frac{Sf^2 - Si^2}{2D} \right| \quad (1)$$

where

D is the distance covered between Si and Sf, in m;

Si is the initial speed, in m/s;

Sf is the final speed, in m/s.

4.1.11 Data evaluation and presentation of results

4.1.11.1 Coefficient of variation

For each tyre and each braking test, the mean and the standard deviation of the mfdd shall be computed and reported.

The coefficient of variation, CV, of a tyre braking test shall be computed as given in Formula (2):

$$\mathrm{CV}\left(\mathrm{tyre}\right) = \frac{\mathrm{Std.dev}\left(\mathrm{tyre}\right)}{\mathrm{Mean}\left(\mathrm{tyre}\right)} \tag{2}$$

4.1.11.2 SRTT weighted variance

Weighted averages (wa) of two successive tests of the SRTT shall be computed taking into account the number of candidate tyres in between.

If R1 is the mean mfdd in the first test of the reference tyre and R2 is the mean mfdd in the second test of the reference tyre, the following operations are performed, according to Table 1.

Table 1 — Calculation of weighted averages

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

"Ta" (a = 1, 2) is the average of the mean mfdd values for a test of a candidate tyre.

4.1.11.3 Snow Grip Index

The Snow Grip Index in percent of a candidate tyre shall be computed as given in Formula (3):

$$\text{Snow Grip Index}\left(\mathrm{candidate}\right) = \frac{\mathrm{Mean}\left(\mathrm{candidate}\right)}{\mathrm{wa}\left(\mathrm{SRTT}\right)} \tag{3}$$

4.1.11.4 Statistical validation

The sets of repeats of measured or computed mfdd for each tyre should be examined for normality, drift, eventual outliers.

The consistency of the means and standard deviations of successive braking tests of SRTT should be examined.

The means of two successive SRTT braking tests shall not differ by more than 5 %.

The coefficient of variation of any braking test shall not be higher than 6 %.

If those conditions are not met, tests shall be performed again after re-grooming the test course.

The SRTT tyres shall be discarded if there is irregular wear or damage or when the performance appears to have been deteriorated.

4.1.12 Snow grip performance comparison between a candidate tyre and a reference tyre using a control tyre

4.1.12.1 General

In the case where the candidate tyres cannot be fitted to the same vehicle as the SRTT, for example, due to tyre size, inability to achieve required loading and so on, comparison shall be made using intermediate tyres, hereinafter referred to as "control tyres", and two different vehicles.

One vehicle shall be capable of being fitted with the SRTT and the control tyre and the other vehicle shall be capable of being fitted with the control tyre and the candidate tyre.

4.1.12.2 Snow Grip Index calculation in case of a control tyre

The Snow Grip Index of the control tyre relative to the SRTT (SG1) and of the candidate tyre relative to the control tyre (SG2) shall be established using the procedure in 4.1.2 to 4.1.11.4.

The Snow Grip Index of the candidate tyre relative to the SRTT shall be the product of the two resulting snow grip indices that is SG1 × SG2.

4.1.12.3 Boundary conditions

The ambient conditions shall be comparable. All tests shall be completed within the same day.

The same set of control tyres shall be used for comparison with the SRTT and with the candidate tyre and shall be fitted in the same wheel positions.

A control tire set is a group of identical tyres made in the same factory during the same production week.

Control tyres that have been used for testing shall subsequently be stored under the same conditions as required for the SRTT.

The SRTT and control tyres shall be discarded if there is irregular wear or damage or when the performance appears to have been deteriorated.

4.2 Braking on snow method for commercial vehicle tyres

4.2.1 General

Snow performance is based on a test method by which the mean fully developed deceleration in a braking test of a candidate tyre is compared to that of a standard reference test tyre.

The relative performance shall be indicated by a Snow Grip Index (SG).

4.2.2 Test course

Same requirements as to 4.1.2 apply.

4.2.3 Vehicle

Same requirements as to 4.1.3 apply.

4.2.4 Standard reference test tyre

The proper reference tyre to be used to evaluate commercial vehicle tyre snow grip performance is ASTM F2872, SRTT 225/75R16C.

4.2.5 Tyres preparation

Fit the test tyres on rims as per ISO 4209-1 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.

The tyres should be prepared prior to testing to remove spew, compound nodules or flashes resulting from the moulding process. The tyre surface in contact with snow shall be clean before performing a test.

Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests. Tyre pressures shall then be adjusted to the values specified for the test.

In case a vehicle cannot accommodate both the reference and candidate tyres, a third tyre ("control" tyre) may be used as an intermediate. First, test the control tyre against the reference on a suitable vehicle, then test the candidate tyre against the control on the selected vehicle.

4.2.6 Tyre load

The vehicle load shall be such that the resulting loads on each of the tyres are between 60 % and 100 % of the load corresponding to the tyres load index.

The static tyre load on the same axle should not differ by more than 10 %.

4.2.7 Tyre inflation pressure

The inflation pressure is calculated to run at constant deflection.

— For a vertical load higher or equal to 75 % of the load capacity of the tyre, a constant deflection is applied, hence the test inflation pressure "P_t" shall be calculated as given in Formula (4):

$$P_t = P_r \left(\frac{Q_t}{Q_r} \right)^{1,25} \tag{4}$$

where

Q_r is the maximum load associated to the load index of the tyre written on the sidewall;

P_r is the reference pressure corresponding to the maximum load capacity Q_r;

Q_t is the static test load of the tyre.

— For a vertical load lower than 75 %of the load capacity of the tyre, a constant inflation pressure is applied, hence the test inflation pressure P_t shall be calculated as given in Formula (5):

$$P_t = P_r \left(0,75\right)^{1,25} = \left(0,7\right) P_r \tag{5}$$

where

P_r is the reference pressure corresponding to the maximum load capacity Q_r.

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

4.2.8 Instrumentation

Same requirements as to 4.1.8 apply.

4.2.9 Testing order and sequences

Same requirements as to 4.1.9 apply.

4.2.10 Test procedure

Same requirements as to 4.1.10 apply.

4.2.11 Data evaluation and presentation of results

4.2.11.1 Coefficient of variation

Same requirements as to 4.1.11.1 apply.

4.2.11.2 SRTT weighted variance

Same requirements as to 4.1.11.2 apply.

4.2.11.3 Snow Grip Index

Same requirements as to 4.1.11.3 apply.

4.2.11.4 Statistical validation

Same requirements as to 4.1.11.4 apply.

4.2.12 Snow grip performance comparison between a candidate tyre and a reference tyre using a control tyre

4.2.12.1 Snow Grip Index calculation in case of a control tyre

Same requirements as to 4.1.12.2 apply.

4.2.12.2 Boundary conditions

Same requirements as to 4.1.12.3 apply.

4.3 Acceleration on snow method for truck and bus tyres

4.3.1 General

Snow performance is based on a test method by which the average acceleration in an acceleration test of a candidate tyre is compared to that of a standard reference test tyre.

The relative performance shall be indicated by a Snow Grip Index (SG).

According to the definition of truck and bus tyres reported into 3.3, the additional classification for the purpose of this test method only applies:

a) Truck and Bus Narrow (TBN), when the tyre nominal section width is lower than 285 mm;

b) Truck and Bus Wide (TBW), when the tyre nominal section width is greater or equal to 285 mm.

4.3.2 Test course

The acceleration tests shall be done on a flat test surface of sufficient length and width, with a maximum 2 % gradient, covered with packed snow.

The snow surface shall be composed of a hard packed snow base at least 3 cm thick and a surface layer of medium packed and prepared snow about 2 cm thick.

The air temperature, measured about one meter above the ground, shall be between –2 °C and –15 °C; the snow temperature, measured at a depth of about one centimetre, shall be between –4 °C and –15 °C.

Air temperature shall not vary more than 10 °C during the test.

It is recommended to avoid direct sunlight, large variations of sunlight or humidity, as well as wind.

The snow compaction index measured according to ASTM F1805 by using a CTI penetrometer shall be between 80 and 90.

The candidate tyre should be tested in the same slope and snow compaction condition as the reference tyre to avoid any advantage or disadvantage for the candidate tyre.

4.3.3 Vehicle

4.3.3.1 General

The test shall be conducted with a two axle standard production vehicle in good running conditions equipped with the following:

a) low rear axle weight and an engine powerful enough to maintain the average percentage of slip during the test as required in 4.3.10.1 and 4.3.10.2;

b) a manual gearbox (automatic gearbox with manual shift allowed) having a gear ratio covering the speed range of at least 19 km/h between 4 km/h and 30 km/h;

c) differential lock on driven axle is recommended as increasing repeatability;

d) a standard commercial system controlling/limiting the slip of the driving axle when accelerating (called Traction Control, ASR, TCS, etc.).

4.3.3.2 Vehicle particular case

In the particular case where a standard production vehicle equipped with a traction control system is not available, a vehicle without Traction Control/ASR/TCS is permitted provided that the vehicle is fitted with a system to display the percentage slip as stated in 4.3.8 and a differential lock on the driven axle used in accordance with the operating procedure 4.3.10.2. If the differential lock is available, it shall be used; however, if the differential lock is not available, the Averaged Slip Ratio should be measured on the left and right driven wheel.

The rear driven axle may be indifferently fitted with two or four test tyres if respecting the loading by tyre.

The front steer non driven axle is equipped with two tyres having a size suitable for the axle load. These two front tyres could be maintained throughout the test.

The permitted modifications applicable to the vehicle are

— those allowing to increase the number of tyre sizes capable to be mounted on the vehicle, and

— those permitting to install an automatic activation of the acceleration and the measurements.

Any other modification of the acceleration system is prohibited.

4.3.4 Standard reference test tyre

Apart from the Candidate tyre dimension (TBN or TBW), the SRTT selection shall be done based on the fitting criteria aimed at making feasible the test execution. For the purpose of this test method and under the proper testing boundary conditions contained hereinafter the two references test tyres, ASTM F2870 and ASTM F2871 are considered equivalent.

4.3.5 Tyres preparation

Fit the test tyres on rims as per ISO 4209-1 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.

The tyres should be prepared prior to testing to remove spew, compound nodules or flashes resulting from the moulding process. The tyre surface in contact with snow shall be clean before performing a test.

Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests. Tyre pressures shall then be adjusted to the values specified for the test.

In case a vehicle cannot accommodate both the reference and candidate tyres, a third tyre ("control" tyre) may be used as an intermediate. First, test the control tyre against the reference on a suitable vehicle, then test the candidate tyre against the control on the selected vehicle.

4.3.6 Tyre load

The static load on each rear driven test tyres should be between 20 % and 55 % of the tested tyre load capacity written on the sidewall.

The vehicle front steer total static axle load should be between 60 % and 160 % of the driven rear total axle load.

The static tyre load on the same driven axle should not differ by more than 10 %.

4.3.7 Tyre inflation pressure

The driven tyres inflation pressure shall be 70 % of the one marked on the sidewall.

The steer tyres are inflated at the nominal pressure marked on the sidewall.

If the pressure is not marked on the sidewall, refer to the specified pressure in applicable tyre standards manuals corresponding to maximum load capacity.

4.3.8 Instrumentation

A sensor suitable for measuring speed and distance covered on snow surface between two speeds shall be used.

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

The following tolerances shall be respected:

a) for speed measurements: ±1 % (km/h) or 0,5 km/h whichever is greater;

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

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

For Acceleration test, a display of the Slip Ratio of the driven tyres is recommended inside the vehicle and shall be used in the particular case of 4.3.3.2.

The Slip Ratio is calculated as given in Formula (6):

$$\text{Slip Ratio}\,(\%) = \left[\frac{\text{Wheel speed} - \text{Vehicle speed}}{\text{Vehicle speed}}\right] \times 100 \tag{6}$$

where

Vehicle speed is measured through the sensors listed above, in m/s;

Wheel speed is calculated on a tyre of the driven axle by measuring its angular velocity and its loaded radius as given in Formula (7)

$$\text{Wheel speed} = 2\pi \times \text{loaded radius} \times \text{angular speed} \quad (7)$$

where

π is 3,1416;

loaded radius is expressed in m;

angular speed is expressed in revolution per second (s^{-1}).

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

4.3.9 Testing order and sequences

For every candidate tyre and the standard reference test tyre, the acceleration test runs shall be repeated a minimum of six times.

The zones where acceleration is fully applied shall not overlap.

When a new set of tyres is tested, the runs are performed after shifting aside the vehicle trajectory in order not to accelerate on the tracks of the previous tyre.

When it is no longer possible not to overlap full acceleration zones, the test course shall be re-groomed.

Order of testing:

— If only one candidate tyre has to be evaluated, the order of testing shall be:

R1 - T - R2

where

R1 is the initial test of the SRTT;

R2 is the repeat test of the SRTT;

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

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

R1 - T1 - T2 – T3 - R2

Required sequence is as follows:

— six SRTT repetitions, then shift aside to test next tyre on fresh surface;

— six Candidate one repetitions, then shift aside;

— six Candidate two repetitions, then shift aside;

— six Candidate three repetitions, then shift aside;

— six SRTT repetitions, then shift aside.

4.3.10 Test procedure

4.3.10.1 General

Drive the vehicle at a constant speed between 4 km/h and 11 km/h and the gear ratio capable of covering the speed range of at least 19 km/h for the complete test program (e.g. R-T1-T2-T3-R).

The recommended gear ratio selected is third or fourth and shall give minimum 10 % Average Slip Ratio in the measured range of speed.

In case of Traction Control System equipped vehicles (already switched "on" before the run), apply full throttle until the vehicle has reached the final speed.

Final speed = Initial speed + 15 km/h.

No rearward restraining force shall be applied to the test vehicle.

Measure the distance between the initial speed and the final speed.

In case of Traction Control System equipped vehicle, the Average Slip Ratio shall be in the range from 10 % to 40 %.

Each time the measurement is repeated, the average acceleration AA ($m \cdot s^{-2}$) is calculated as given in Formula (8):

$$AA = \frac{Sf^2 - Si^2}{2D} \tag{8}$$

where

D is the distance covered between Si and Sf, in m;

Si is the initial speed, in m/s;

Sf is the final speed, in m/s

4.3.10.2 Vehicle without Traction Control System

In the particular case of 4.3.3.2 where a standard production vehicle equipped with a Traction Control System is not available, the driver maintains manually the Averaged Slip Ratio range for each test run between 10 % and 40 % (Controlled Slip procedure in place of the Full Slip) within the prescribed range of speeds. If a differential lock is not available, the Averaged Slip Ratio difference between the left and right driven wheel shall not be higher than 8 % for each run. All the tyres and runs in the test session are performed with Controlled Slip procedure.

4.3.11 Data evaluation and presentation of results

4.3.11.1 Coefficient of variation

The coefficients of variation of the average acceleration are calculated for all the candidate tyres. If one coefficient of variation is higher than 6 %, discard the data for this candidate tyre and repeat the test.

$$CV\left(\text{tyre}\right) = \frac{\text{Std.dev}\left(\text{tyre}\right)}{\text{Mean}\left(\text{tyre}\right)} \tag{9}$$

If the coefficient of variation of the average acceleration "AA" for each group of minimum of six runs of the reference tyre is higher than 6 %, discard all data and repeat the test for all tyres (the candidate tyres and the reference tyre).

4.3.11.2 SRTT stability coefficient

In addition and in order to take into account possible test evolution, the stability coefficient is calculated on the basis of the average values of any two consecutive groups of minimum of six runs of the reference tyre.

If the stability coefficient is higher than 6 %, discard the data for all the candidate tyres and repeat the test.

$$\text{Stability coefficient} = \left| \frac{\text{Average2} - \text{Average1}}{\text{Average1}} \right| \quad (10)$$

4.3.11.3 Calculation of the "average AA"

If R1 is the average of the "AA" values in the first test of the reference tyre, R2 is the average of the "AA" values in the second test of the reference tyre, the following operations are performed, according to Table 2.

Table 2 — Calculation of average acceleration (AA)

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

"Ta" (a = 1, 2, …) is the average of the AA values for a test of a candidate tyre.

4.3.11.4 Acceleration force coefficient (AFC) calculation

Calculation of AFC(Ta) and AFC(Ra) as defined in Table 3.

Table 3 — Calculation of the Acceleration Force Coefficient (AFC)

	The Acceleration Force Coefficient "AFC" is
Reference tyre	AFC(R) = Ra/g
Candidate tyre	AFC(T) = Ta/g
NOTE 1 Ra and Ta are expressed in m/s^2.	
NOTE 2 "g" = gravity acceleration (rounded to 9,81 m/s^2).	

4.3.11.5 Snow Grip Index

The Snow Grip Index represents the relative performance of the candidate tyre compared to the reference tyre.

$$\text{Snow Grip Index}\left(T\right) = \frac{\text{AFC}\left(T\right)}{\text{AFC}\left(R\right)} \quad (11)$$

4.3.11.6 Calculation of the Slip Ratio

The Slip Ratio can be calculated as the average of Slip Ratio as 4.3.8 or by comparing the average distance of the minimum six runs to the distance of a run done without slip (very low acceleration), as given in Formula (12):

$$\text{Slip Ratio}\,(\%) = \left[\frac{\text{Average distance} - \text{No slip distance}}{\text{No slip distance}}\right] \times 100 \tag{12}$$

No slip distance means that the wheel distance is calculated on a run done with a constant speed or on a continuous low acceleration.

4.3.12 Snow grip performance comparison between a candidate tyre and a reference tyre using a control tyre

4.3.12.1 Snow Grip Index calculation in case of a control tyre

Same requirements as to 4.1.12.2 apply.

4.3.12.2 Boundary conditions

Same requirements as to 4.1.12.3 apply.