China Domestic Test and Verification Research of Wet Grip Performance of C1 Tire Based on ECE R117

Rongliang LIANG [1, a*], Lin YUAN [1, b], Mingqiu GAO[1, C]

[1]China Automotive Technology and Research Center, Tianjin, China

[a]liangrongliang@catarc.ac.cn, [b]yuanlin@catarc.ac.cn, [C]gaomingqiu@catarc.ac.cn,

Keywords: ECE R117; C1 tire; Wet grip performance; Test and verification

Abstract. The test method for C1 tire wet grip performance based on European ECE R117 is analyzed, combined with the characteristics of China domestic proving ground, the test and evaluation process and test ability for C1 tire wet grip performance has already been established, which has great reference significance for the formulation standard for the test evaluation and classification of tire performance.

Preface

The tire imported into EU market must meet the requirements of ECE R117 except requiring the regular ECE R30 and ECE R54 from Oct. 1 2009 according ECE R117 issued by Economic Commission for Europe (ECE) on April 6, 2005. The European Commission also issued the related tire label regulation EC 1222/2009 which requests that the tire sold in EU must be labeled in order to indicate the classification of tire rolling resistance, wet grip performance and rolling noise exactly according ECE R117 [1], meanwhile, the testing and certification for snow tire and special tire labeled Alpine become more and more mature.

With the business expansion of some famous international tire enterprises (Michelin) in domestic market, all kinds of advanced tire test methods, such as tire wear resistance, tire limited adhesion condition, rolling resistance, tire environmental performance, tire comfort performance and tire snow and ice grip performance, have been adopted by domestic tire enterprises. The tire comprehensive performance evaluation becomes stricter in domestic tire enterprises such as Zhongce Rubber and MAXXIS, and the service need for tire testing and certification becomes more and more strong combined with the large scale of domestic vehicles and tires exportation to USA and EU.

The related national standards of tire wet braking, rolling resistance, rolling noise, though issued by Chinese government, are all recommended standards other than compulsory execution, and the related standards have not been implied completely due to lack of SRTT and test site. The vehicle test centers focus on the field of whole vehicle testing and certification, the tire test centers focus on the field of tire testing and certification, therefore, there is no one quality supervision and inspection center which can qualify full scale testing ability completely.

Tire wet grip performance testing method using an instrumented passenger car by ECE R117

Type of tire by ECE R117

Class C1 tires: Tires conforming to ECE Regulation No.30 [2]. In case of tires submitted for approval of performance adhesion on wet surfaces, whether normal tires or snow tires with a speed

category of Q or below excluding H (≤ 160 km/h) or speed category R and above including H (>160 km/h);

Class C2 tires: Tires conforming to ECE Regulation No.54 [3] and identified by a load capacity index in single formation lower or equal to121 and a speed category symbol higher or equal to "N";

Class C3 tires: Tires conforming to ECE Regulation No. 54 and identified by: A load capacity index in single formation higher or equal to 122; or A load capacity index in single formation lower or equal to 121 and a speed category symbol lower or equal to "M".

To new pneumatic tires of Class C1 with regard to adhesion performance on wet surfaces (wet adhesion). It does not, however, apply to:

Tire designed as "Temporary use spare tire" and marked "Temporary use only";

Tire having a nominal rim diameter code⩽10 (or⩽254 mm) or⩾25 (or ⩾635 mm);

Tire designed for competitions;

Tire intended to be fitted to road vehicles of categories other than M, N and O;

Tire fitted with additional devices to improve traction properties;

Tire with a speed rating less than 80 km/h;

Tire designed only to be fitted to vehicles registered for the first time before 1 October 1990;

Professional off-road tire for the requirements on rolling resistance and rolling sound.

Type of Standard Reference Test Tire (SRTT)

SRTT 14'' for C1 tire

This specification covers the general requirements for the P195/75R14 radial standard reference test tire according to ASTM E1136-2010"Standard Specification for P195/75R14 Radial Standard Reference Test Tire" [4]. The tire covered by this specification is primarily for use as a reference tire for braking traction, snow traction, and wear performance evaluations, but may also be used for other evaluations, such as pavement roughness, noise, or other tests that require a reference tire. This method adopted by ECE R117 uses the reference tire that has the characteristics indicated in the ASTM E 1136 and referred to as SRTT14", the average peak braking force coefficient (PBFC) of the SRTT14" shall be 0.7 ± 0.1 at 65 km/h.

SRTT 16'' for C1 tire

This specification covers the general requirements for the P225/60R16 97S radial standard reference test tire according to ASTM F2493-2008 "Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire" [5]. SRTT 16'' has been used as reference tire during the wet grip performance for C1 tire according to ECE R 117.

SRTT 16'' for C2 tire

This specification covers the general requirements for the 225/75R16C 116/114S radial standard reference test tire according to ASTM F2872-2011 "Standard Specification for 225/75R16C 116/114S M+S Radial Light Truck Standard Reference Test Tire" [6]. This SRTT 16" for C2 tire will be used as reference tire during the wet grip performance for C2 tire according to ISO 15222-2011 "Truck and bus tire-Method for measuring relative wet grip performance-Loaded new tire".

SRTT 19.5'' for C3 tire

This specification covers the general requirements for the 245/70R19.5 136/134M radial standard reference test tire according to ASTM F2871-2011 "Standard Specification for 245/70R19.5 136/134M Radial Truck Standard Reference Test Tire" [7]. This SRTT 19.5" for C3 tire will be used as reference tire during the wet grip performance for C3 tire (section width is less than 285 mm) according to ISO 15222-2011"Truck and bus tire—Method for measuring relative wet grip performance-Loaded new tire".

SRTT 22.5'' for C3 tire

This specification covers the general requirements for the 315/70R22.5 154/150L radial standard reference test tire according to ASTM F2870-2011 "Standard Specification for 315/70R22.5 154/150L Radial Truck Standard Reference Test Tire" [8]. This SRTT 22.5" for C3 tire will be used as reference tire during the wet grip performance for C3 tire (section width is more than 285 mm) according to ISO 15222-2011"Truck and bus tire-Method for measuring relative wet grip performance-Loaded new tire" [9].

An instrumented passenger car used for testing

The testing method covers a procedure for measuring the deceleration performance of C1 tire during braking, using an instrumented passenger car equipped with an Antilock Braking System (ABS), where 'instrumented passenger car' means a passenger car that is fitted with the measuring equipment for the purpose of this testing method. Starting with a defined initial speed, the brakes are applied hard enough on four wheels at the same time to activate the ABS. The average deceleration is calculated between two pre-defined speeds.

Meanwhile, the instrumented passenger car wheelbase should be less than 3.5m when equipped with C1 tires, and permitted modifications on the passenger car are as follows:

Those allowing the number of tire sizes that can be mounted on the vehicle to be increased;

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

Any other modification of the braking system is prohibited.

Test condition

Conditioning of test track

The surface shall have a dense asphalt surface with a uniform gradient of not more than 2 per cent and shall not deviate more than 6 mm when tested with a 3 m straight edge. The surface shall have a pavement of uniform age, composition and wear. The test surface shall be free of loose material and foreign deposits. The maximum chipping size shall be 10 mm (tolerances permitted from 8 mm to 13 mm). The texture depth as measured by a sand patch shall be 0.7 ± 0.3 mm. It shall be measured in accordance with ASTM E 965-96 (Reapproved 2006).

The test track surface shall be watered at least half an hour prior to testing in order to equalize the surface temperature and water temperature. External watering should be supplied continuously throughout testing. For the whole testing area, the water depth shall be 1.0 ± 0.5 mm, measured from the peak of the pavement. The test track should then be conditioned by conducting at least ten test runs with tire not involved in the test program at 90 km/h.

Atmospheric conditions

The wind conditions shall not interfere with wetting of the surface (wind-shields are allowed). Both the wetted surface temperature and the ambient temperature shall be between 2°C and 20°C for snow tire and 5°C and 35°C for normal tire. The wetted surface temperature shall not vary during the test by more than 10°C. The ambient temperature must remain close to the wetted surface temperature; the difference between the ambient and the wetted surface temperatures must be less than 10°C.

Tires and rims

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

The test tire shall be mounted on the test rim declared by the tire manufacturer. A proper bead seat should be achieved by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tire on the wheel rim.

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

The static load and inflation pressure on each axle tire are shown in table 1. Tire loads on the same axle should not differ by more than 10 percent, and tire pressure should be checked just prior to testing at ambient temperature and adjusted if required.

Table 1 the static load on each axle tire and the inflation pressure

Tire type	Inflation pressure /kPa	Static load /kg
SRTT	220	60～90% of tested tire load capacity
Tested tire	220	60～90% of tested tire load capacity

Test procedure

Test run

The passenger car is driven in a straight line up to 85 ± 2 km/h. Once the passenger car has reached 85 ± 2 km/h, the brakes are always activated at the same place on the test track referred to as 'braking starting point', with a longitudinal tolerance of 5 m and a transverse tolerance of 0.5 m.

The brakes are activated either automatically or manually. The manual activation of the brakes depends on the type of transmission as follows. In both cases, a minimum of 600 N pedal efforts is required.

For manual transmission, the driver should release the clutch and depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

For automatic transmission, the driver should select neutral gear and then depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

The average braking distance measured between 80 km/h and 20 km/h is used to calculate the mean fully developed deceleration (MFDD), as shown in the following formula:

$$MFDD=231.48/S \quad (1)$$

Where:

MFDD is the mean fully developed deceleration, unit of which is m/s^2. S is the braking distance measured between 80 km/h and 20 km/h, unit of which is meter.

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

Test cycle

A number of test runs are made in order to measure the wet grip index of a set of candidate tire according to the following procedure, whereby each test run shall be made in the same direction and up to three different set of candidate tire may be measured within the same test cycle.

The set of reference tires are mounted on the instrumented passenger car. After at least three valid measurements have been made, the set of reference tires are replaced by a set of candidate tires. After six valid measurements of the candidate tires are performed, two more set of candidate tires may be measured. The test cycle is closed by three more valid measurements of the same set of reference tires as at the beginning of the test cycle. Therefore, there are three kinds of test cycle as shown in the following:

R1-T1-R2, R1-T1-T2-R2 and R1-T1-T2-T3-R2

Where:

R1 is the initial test of the SRTT; R2 is the repeat test of the SRTT; T1, T2 and T3 stand for three different set of candidate tires to be evaluated.

Processing and validation of test results

For each set of tested tires (both reference tires and candidate tires), the mean and standard deviation of the MFDD shall be computed and reported separately. The coefficient of variation (CV) of one set of tested tires shall be less than 3 percent, calculated as the following formula:

$$CV = (Std.dev/Mean)*100\% \quad (2)$$

Where:

CV is the coefficient of variation; Std.dev is the Standard deviation of MFDD; and Mean is the average of MFDD.

The weighted adjusted MFDD of SRTT to be used in the comparison of the performance of the candidate tire has been shown in the following table 2 according to the positioning of each candidate tire set in a given test cycle.

Table 2 the weighted adjusted MFDD of SRTT

Test cycle	mean MFDD of candidate tire ($m.s^{-2}$)	weighted adjusted MFDD of SRTT ($m.s^{-2}$)
R1-T1-R2	t_1	$(R_1+R_2)/2$
R1-T1-T2-R2	t_1	$2/3R_1+1/3R_2$
	t_2	$1/3R_1+2/3R_2$
R1-T1-T2-T3-R2	t_1	$3/4R_1+1/4R_2$
	t_2	$1/2(R_1+R_2)$
	t_3	$1/4R_1+3/4R_2$

Where:

t is the actual average of MFDD for the candidate tire to be evaluated. t_1,t_2,t_3 stand for the three different sets of candidate tire, R_1 is the average of MFDD in the first test of the reference tire set (R1) and R_2 is the average of MFDD in the second test of the reference tire set (R2).

Calculation of the wet grip index of the candidate tire

The average braking force coefficient of candidate tire set are calculated and adjusted in the following table 3 according to the positioning of each candidate tire set in a given test cycle.

Table 3 the average braking force coefficient of candidate tire

Test cycle	BFC(T)	BFC(R)
R1-T1-R2	t_1/g	[（R_1+R_2）/2]/g
R1-T1-T2-R2	t_1/g	[2/3R_1+1/3R_2]/g
	t_2/g	[1/3R_1+2/3R_2]/g
R1-T1-T2-T3-R2	t_1/g	[3/4R_1+1/4R_2]/g
	t_2/g	[1/2（R_1+R_2）]/g
	t_3/g	[1/4R_1+3/4R_2]/g

Where:

BFC (T) is the actual average braking force coefficient of candidate tire set, BFC (R) is the weighted average braking force coefficient of reference tire set to be used in the comparison of the performance of the candidate tire set.

The wet grip index of the candidate tire G(T) is calculated as follows:

$$G(T)=\left[\frac{BFC(T)}{BFC(R)}\times 125+a\times(t-t_0)+b\times\left(\frac{BFC(R)}{BFC(R_0)}-1.0\right)\right]\times 10^{-2} \quad (3)$$

Where:

t is the measured wet surface temperature in degree Celsius when the candidate tire (T) is tested;

t_0 is the wet surface reference temperature condition, t_0=20°C for normal tire and t_0=10°C for snow tire;

BFC(R_0) is the braking force coefficient for the reference tire in the reference conditions, BFC(R_0) = 0.68;

a= -0.4232 and b = -8.297 for normal tire, a = 0.7721 and b = 31.18 for snow tire [a is expressed as (1/°C)].

The selection of tested vehicle, rims and candidate tires

tested vehicle selection

Based on the passenger car class division (as shown in table 4) and their suitable tire specification, the tire section width of class A_{00}、class A_0、class A、class B and class C passenger cars covers 175mm、185 mm、195 mm、205 mm、215 mm、225 mm; the nominal rim diameter code covers 14-inch、15-inch、16-inch and 17-inch; and the nominal rim width code covers 5.5J、6.0J、6.5J and 7.0J. The candidate tires and matched rims are shown in table 5 below.

Table 4 Passenger car class division

Class	Wheel base/m	Engine capacity/L
A_{00}	2.00~2.20	＜1.0
A_0	2.20~2.30	1.0~1.3
A	2.30~2.45	1.3~1.6
B	2.45~2.60	1.6~2.4
C	2.60~2.80	2.4~3.0
D	＞2.80	＞3.0

Table 5 the candidate tires and matched rims

Rim width code/inch	Tire section width /mm		
	suitable	best	suitable
5.0J	165	175	185
5.5J	175	185	195
6.0J	185	195	205
6.5J	195	205	215
7.0J	205	215	225
7.5J	215	225	235
8.0J	225	235	245
8.5J	235	245	255
9.0J	245	255	265
9.5J	265	275	285
10.0J	295	305	315
10.5J	305	315	325

To reflect the wet grip performance of the mainstream C1 tires assembled to the domestic passenger car objectively and scientifically, the candidate tire section width must cover the above 6 section width series as much as possible. Therefore, one test passenger car is selected from B class division. All the above 6 specification tires can be equipped to the vehicle by the way of upgrading rim and downgrading rim. The parameter of test vehicle is shown in table 6, and testing site condition is shown in figure 1 and figure 2.

Table 6 the parameter of test vehicle

Vehicle	SVW7166GSD	Engine power rating (kw)	77
Manufacturer	SWV	Curb weight (kg)	1285 738/547
Brand	Octavia	Gross vehicle weight (kg)	1660 848/812
Production	2012	Rim code	16×6.5J
Engine series	000930	Rim PCD/mm	5×112
VIN	LSVN121Z2C2000535	Rim center bore diameter /mm	57.1
Vehicle type	M1	Rim offset /mm	50

Figure 1 the testing site of wet track

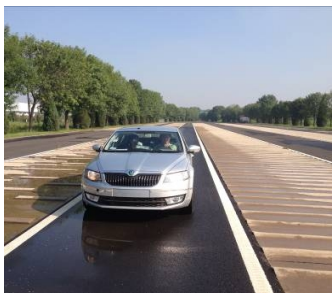

Figure 2 tested vehicle during test

The rims selection

Octavia passenger car fitted 16×6.5J rim code is suitable for tire model 205/55R16, can also be suitable for the tire section width of185mm、195mm、205mm、215mm and 225mm. The rims and the suitable matched tire model are shown in the following table 7.

To improve the test efficiency and keep test data scientific and impartiality, also to avoid the inefficiency and high resources consumption by the indirect method using intermediate tire as the reference tire, the rim code of 14×6.0J is purchased to equip with reference tire model P195/75R14 and candidate tire model 175/65R14, and then the 14×6.0J rim is fitted to Octavia test vehicle by adding a 15mm thickness of flange to the installation surface to adjust the rim offset.

There will be enough clearance between the original rim and suspension system, between the original tire and fender to allowance ±5mm fluctuation of rim offset , therefore, it is not necessary to fit the spacer when the tire section width of 185mm、195mm、205mm、215mm and 225mm are tested.

Table7 the rims and suitable matched tire model

Rim code	14×6.0J	15×6.0J	15×6.5J	16×6.5J	16×7.0J	17×7.0J	17×7.5J
PCD /mm	5×112	5×112	5×112	5×112	5×112	5×112	5×112
Rim center bore diameter /mm	57.1	66.6	57.1	57.1	57.1	57.1	66.4
Rim offset/mm	+38	+46	+45	+50	+45	+45	+45
Matched tire model	175/65R14	185/60R15	195/65R15	205/55R16	215/60R16	225/45R17	225/45R17

Candidate tire and SRTT selection

For the special requirement of domestic market, the selected candidate tires involved 14 sets of candidate tires and 9 mainstream brands, are shown in the following table 8, which covers the tire section width of 175mm、185mm、195mm、205mm、215mm、225mm. Based on the selection of the tested vehicle and rims code, the wet grip performance of different mainstream candidate tires is analyzed selectively. P225/60R16 97S radial standard reference test tire specified in ASTM F2493-2008 Standard is adopted as the reference tire according to annex 5 of ECE R117.

Table 8 the parameters of selected candidate tires

Tire brand	Hankook	ChaoYang	Bridgestone	Pirelli	Michelin	Continental	ChaoYang
Tread patten	Winter icept	SW618	BLIZZAK REVOGZ	ICECONTROL	X-ICE	Contiviking Contract 5	SW 608E
Snow label	Alps M+S	Alps M+S	M+S	Alps M+S	Alps M+S	Alps M+S	Alps M+S
Tire model	175/65R14	175/65R14	185/60R15	185/60R15	195/65R15	205/55R16	205/55R16
Rim code	14×6.0J	14×6.0J	15×6.0J	15× 6.0J	15×6.5J	16×6.5J	16×6.5J
Speed symbol	Q	T	S	T	T	T	H
Load index	82	82	84	88	95	94	91
Max.load capacity	1900	1900	2000	2240	2760	2680	2460
60% TLCC	285	285	300	336	414	402	369
90% TLCC	427.5	427.5	450	504	621	603	553.5
60% Max.load capacity	1140	1140	1200	1344	1656	1608	1476
90% Max.load capacity	1710	1710	1800	2016	2484	2412	2214
Tested vehicle mass/Max.loading capacity	0.87	0.87	0.83	0.74	0.60	0.62	0.67
Tire brand	LANDSAIL	DoubleCoin	LANDSAIL	DoubleCoin	Pirelli	Hankook	Michelin
Tread patten	WINTER LANDER	Warrior WR200	WINTER LANDER	Warrior WR200	ICECONTROL	Winter RAFT ice Wi61	X-ICE
Snow label	Alps M+S	M+S	Alps M+S	M+S	Alps M+S	M+S	Alps M+S
Tire model	205/55R16	205/55R16	205/55R16	215/60R16	225/45R17	225/45R17	225/45R17
Rim code	16×6.5J	16×6.5J	16×6.5J	16×7.0J	17×7.0J	17×7.0J	17×7.5J
Speed symbol	H	T	H	T	T	R	H
Load index	91	91	91	95	94	91	94
Max.load capacity	2460	2460	2460	2760	2680	2460	2680
60% TLCC	369	369	369	414	402	369	402
90% TLCC	553.5	553.5	553.5	621	603	553.5	603
60% Max.load capacity	1476	1476	1476	1656	1608	1476	1608
90% Max.load capacity	2214	2214	2214	2484	2412	2214	2412
Tested vehicle mass/Max.loading capacity	0.67	0.67	0.67	0.60	0.62	0.67	0.62
60%~90%Max.loading capacity	1656～1710						
Tested vehicle mass	1660（GVW）=840（Front axle weight）+820（Rear axle weight）						

Pre-preparation before test

Test vehicle loading

The vehicle load shall be such that the resulting loads on the tires are between 60 percent and 90 percent of the load corresponding to the tire load index according to Annex 5 of ECE R117, which are shown in table 8. All the measurement loading information is listed in the table 8 including 60% TLCC, 90% TLCC, 60% Max.load capacity, 90% Max.load capacity and 60%~90%Max.loading capacity. During the whole test cycle, the loading distribution must stick to a unique principle which is “uniform load, changing candidate tire as the same load and same test engineer” to avoid the influence to the test data because of the wave of vehicle load.

The analysis of friction characteristics on the test track

SRTT P195/75R14 for C1 tires defined in ASTM E1136-93(2003) standard [10] is used to test the friction characteristics on the wet test track according to ISO 8349:2002 [11] and Annex 5 of ECE R117. The tested vehicle first would be accelerated to 85km/h and kept in a stable running condition, and then the power transmission will be disconnected and emergency braking force will be implied on the braking pedal in order to activate ABS system, the braking distance from 80 km/h to 50 km/h will be used to calculated the average peak braking force coefficient at the speed of 65 km/h, which are shown in the following table 9 and figure 3.

Table 9 the friction characteristics of test track by SRTT 14”

Friction characteristics of dry test track (80-50 km/h)				Friction characteristics of wet test track (80-50 km/h)		
Test cycle	Braking distance/m	PBFC	Adjusted PBFC	Braking distance/m	PBFC	Adjusted PBFC
1	24.4	0.63	0.69	20.5	0.75	0.86
2	25.0	0.61	0.68	19.6	0.78	0.89
3	25.0	0.61	0.68	20.4	0.75	0.86
4	25.4	0.60	0.67	20.6	0.75	0.85
5	26.1	0.59	0.65	19.6	0.78	0.89
6	24.1	0.64	0.70	20.3	0.76	0.86
Validate value	25.0	0.61	0.68	20.2	0.76	0.87

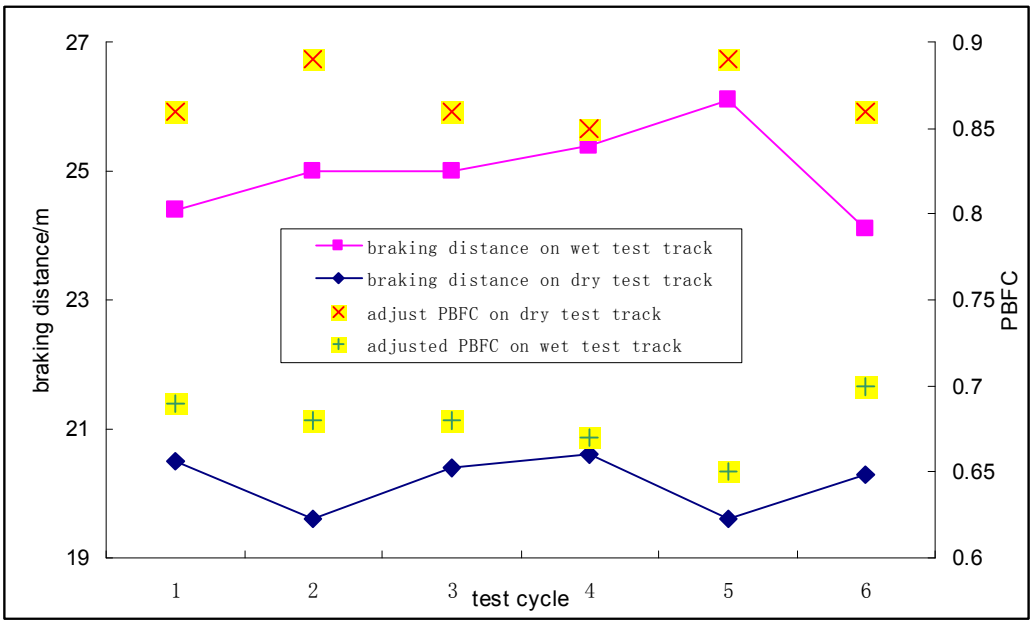

Figure 3 the friction characteristics of test track by SRTT 14”

The PBFC adjusted by the temperature of test track will meet the special friction characteristics requirement of test track if it reaches in range of 0.6 to 0.8 according to Annex 5 of ECE R117. Figure 3 show that the difference of braking distance on wet test track is 2 meters with the tolerance of 8.3 percent, while the difference of braking distance on dry test track is 1 meter with the tolerance of 5.1 percent. The difference of adjusted PBFC on wet test track by temperature is 0.05, the tolerance between the max and min of which is 7.7 percent, while the difference of adjusted PBFC on dry test track by temperature is 0.04, the tolerance between the max and min of which is 4.7 percent. Therefore, the friction characteristics of dry test track is more consistent and repeatable than wet test track no matter the braking distance or adjusted PBFC.

Evaluation of wet grip performance

Form the consideration of intellectual property protection and commercial technical security, 3 sets of candidate tires selected at random from 2 tire brands (LANDSAIL and Double Coin) are tested and evaluated for the wet grip performance, the section width of which covers 205 and 215.

The results of test data and test evaluation are shown in the following figure 4、figure5 and table 10. T1 stands for the set of candidate tire whose section width is 215 mm; T2 and T3 stand for the two sets of candidate tires, both of which section width are 205 mm.

In order to reduce the influence to the test data because of any occasional changes of test vehicle, test track and meteorological environment during the test, all the test data based on Annex 5 of ECE R117 has been optimized, every one set of candidate tire repeats eight tests, by removing the best and the worst test data and keeping the remain six validate test results using for the following test evaluation, while the reference tire repeats six tests, also removing the best and the worst test data and keeping the remain four validate test results using for the following test evaluation.

Table 10 testing and evaluation of candidate tire

Testing time	Braking distance /m					MFDD/(m · s^{-2})				
	R1	T1	T2	T3	R2	R_1	t_1	t_2	t_3	R_2
1	33.0	34.9	32.3	31.7	33.0	7.01	6.63	7.17	7.30	7.01
2	31.4	35.1	30.3	31.9	31.4	7.37	6.59	7.64	7.26	7.37
3	32.6	36.2	31.2	32.9	32.6	7.10	6.39	7.42	7.04	7.10
4	31.1	34.9	31.1	32.5	31.1	7.44	6.63	7.44	7.12	7.44
5		36.0	32.1	33.2			6.43	7.21	6.97	
6		35.9	31.3	31.6			6.45	7.40	7.33	
Average value	32.0	35.5	31.4	32.3	32.0	7.23	6.52	7.38	7.17	7.23
Std.dev						0.187	0.110	0.172	0.147	0.187
CV(≤3%)						2.58	1.68	2.33	2.05	2.58
BFC(T)							0.66	0.75	0.73	
BFC(R)							0.74	0.74	0.74	
G(T)(≥1.07)							0.98	1.12	1.08	

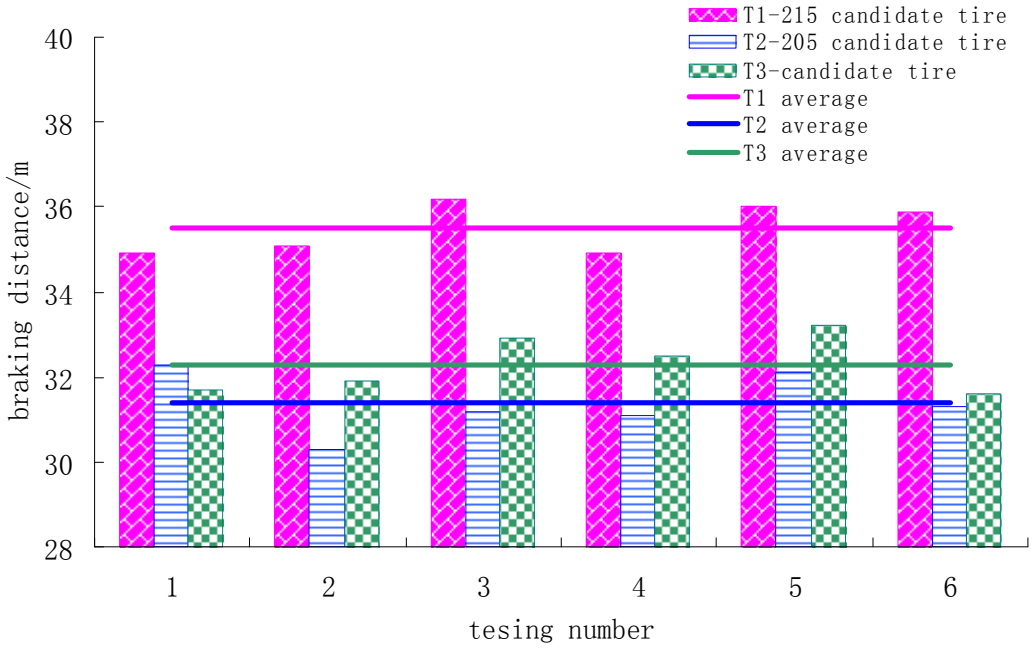

Figure 4 the braking distance of candidate tires

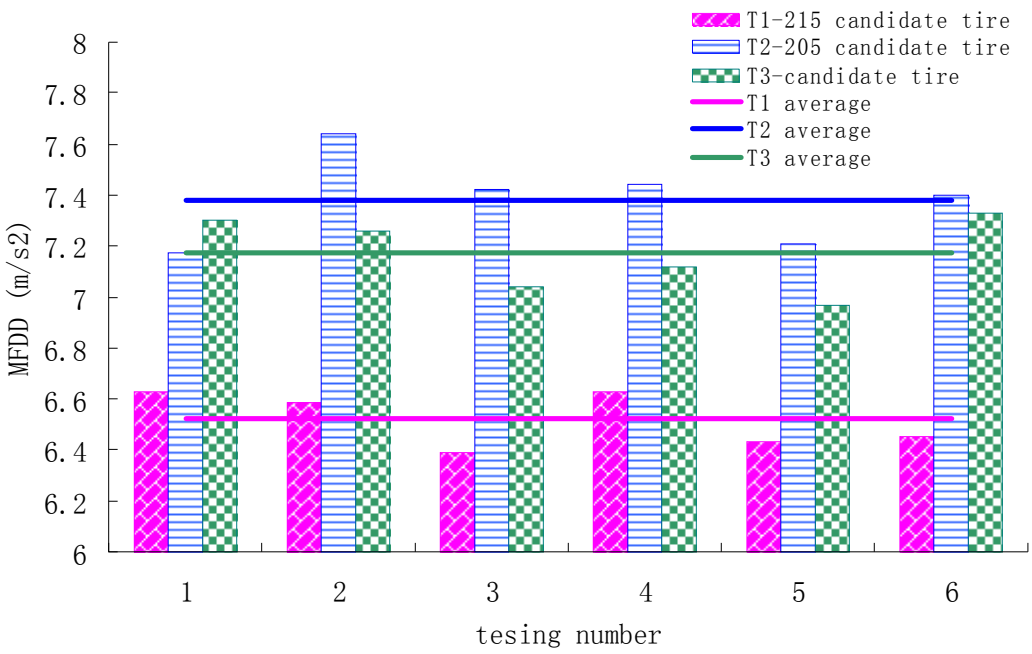

Figure 5 the MFDD of candidate tires

All the test results (ex. Braking distance and MFDD) of both candidate tire and reference tire are consistent and repeatable delicately as shown in table 10, and the validate CV values are less than 3 percent specified by standard test procedure. Figure 4 and figure 5 shows the detail comparison of braking distance and MFDD about all the tested tires. The braking distance difference of T1 candidate tire between the max and min among the six validate tests is 1.3 meters with the tolerance of 3.7 percent; The braking distance difference of T2 candidate tire between the max and min among the six validate tests is 2.0 meters with the tolerance of 6.6 percent; while The braking distance difference of T3 candidate tire between the max and min among the six validate tests is 1.6 meters with the tolerance of 5.1 percent. The MFDD difference calculated by braking distance of T1 candidate tire is 0.24 with the tolerance of 3.8 percent; The MFDD difference calculated by braking distance of T2 candidate tire is 0.47 with the tolerance of 6.6 percent; while the MFDD difference calculated by braking distance of T3 candidate tire is 0.36 with the tolerance of 5.2 percent. Therefore, the tolerance of MFDD is consistent compared with the tolerance of braking distance.

There may be some differences in track residual existed in tire tread and void ratio between different test sequences, which may influences the repeatability of testing and certification. Meanwhile, there may be micro changes of pavement compaction in the braking test track, all of the above index leads to the micro wave of braking distance and MFDD. Therefore, there is 3 percent tolerance of CV difference during the testing on candidate tire and reference tire.

Conclusions

Nowadays all kinds of tire are designed and researched by domestic tire manufacturers according to the market requirements. However, the test methods and standards for the wet grip performance are still defective. The EU and USA have already owned their mature technology for the field of C1 wet grip performance, and the standards for C2 and C3 wet grip performance are on

the process of revision. Therefore, it is necessary to trace and analyze the relevant international standards, which has great reference and guidance significance for the design and research of related products and the relevant standard revision.

All the test research bases on the major scientific research project "The Objective Evaluation System Research on Tire Test", which is a major special Five-year automotive test platform of CATARC. All the objective evaluation indexes of tire test are analyzed deeply, and the relevant evaluation indexes database used for the domestic tire classification is also built during test. The main purpose is to build the tire classification method suitable for the domestic tire condition which can promote the relevant technology improvement.

The tire test of wet grip performance is carried out in CATARC proving ground to build the tire test technical platform shared with domestic tire manufacturers, and to build the technical reserve preparing for enlarging the domestic tire test market and export certification market. The main purpose of tire test is to expand CATARC international influence in the field of tire testing and certification, and to set up the objective evaluation system for tire based on tire regular testing, vehicle and tire performance development, proving ground technical service.

Acknowledgements

This work was financially supported by the major scientific research project "The Objective Evaluation System Research of Tire Test", which is the major special Five-year automotive test platform of CATARC. Project Series Number is CATARC13140101.

References

[1] ECE R117-2013 "Uniform Provisions concerning the Approval of Tires with regard to Rolling Sound Emissions and/or to Adhesion on Wet Surfaces and/or to Rolling Resistance";
[2] ECE R30-2007 "UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PNEUMATIC TYRESFOR MOTOR VEHICLES AND THEIR TRAILERS";
[3] ECE R54-2003"UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PNEUMATIC TYRESFOR COMMERCIAL VEHICLES AND THEIR TRAILERS";
[4] ASTM E1136-2010"Standard Specification for P195/75R14 Radial Standard Reference Test Tire";
[5] ASTM F2493-2008 "Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire"
[6] ASTM F2872-2011 "Standard Specification for 225/75R16C 116/114S M+S Radial Light Truck Standard Reference Test Tire";
[7] ASTM F2871-2011 "Standard Specification for 245/70R19.5 136/134M Radial Truck Standard Reference Test Tire";
[8] ASTM F2870-2011 "Standard Specification for 315/70R22.5 154/150L Radial Truck Standard Reference Test Tire";
[9]ISO15222:2011"Truck and bus tire-Method for measuring relative wet grip performance-Loaded new tire";
[10] ASTM E1136-2010 "Standard Specification forP195/75R14 Radial Standard Reference Test Tire";
[11] ISO 8349:2002 "Road vehicles-Measurement of road surface friction";