



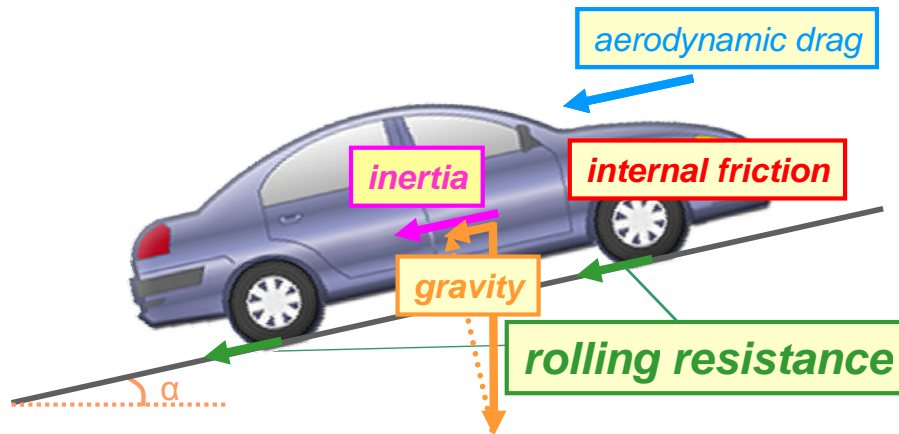
# **Implementation of Rolling Resistance** **in R117**

- Tyre Rolling Resistance
- Rolling Resistance measuring methods
- Calibration of RR Machines
- Questions raised during GRB meeting July 23

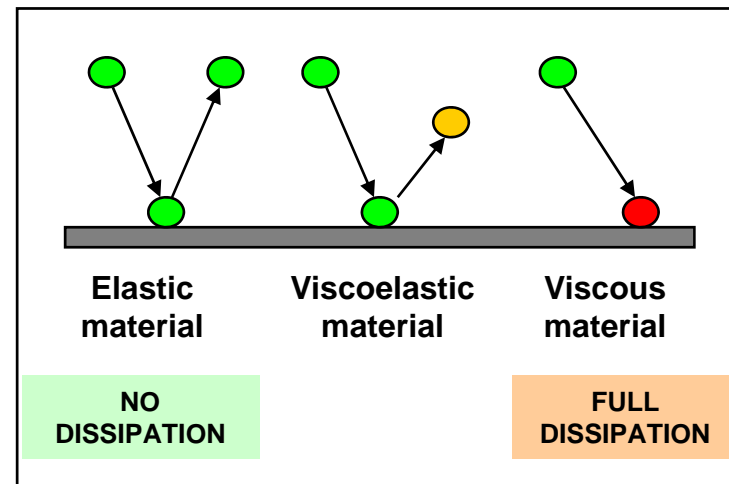


# Tyre Rolling Resistance

Rolling Resistance is one of the forces acting on a vehicle:



Rubber compounds are visco-elastic materials. Each time they are deformed they dissipate energy:



RR is a force acting opposite to the travel direction if a tyre is rolling. Due to the vehicle load, the tyre is deformed in the contact area with the road surface.

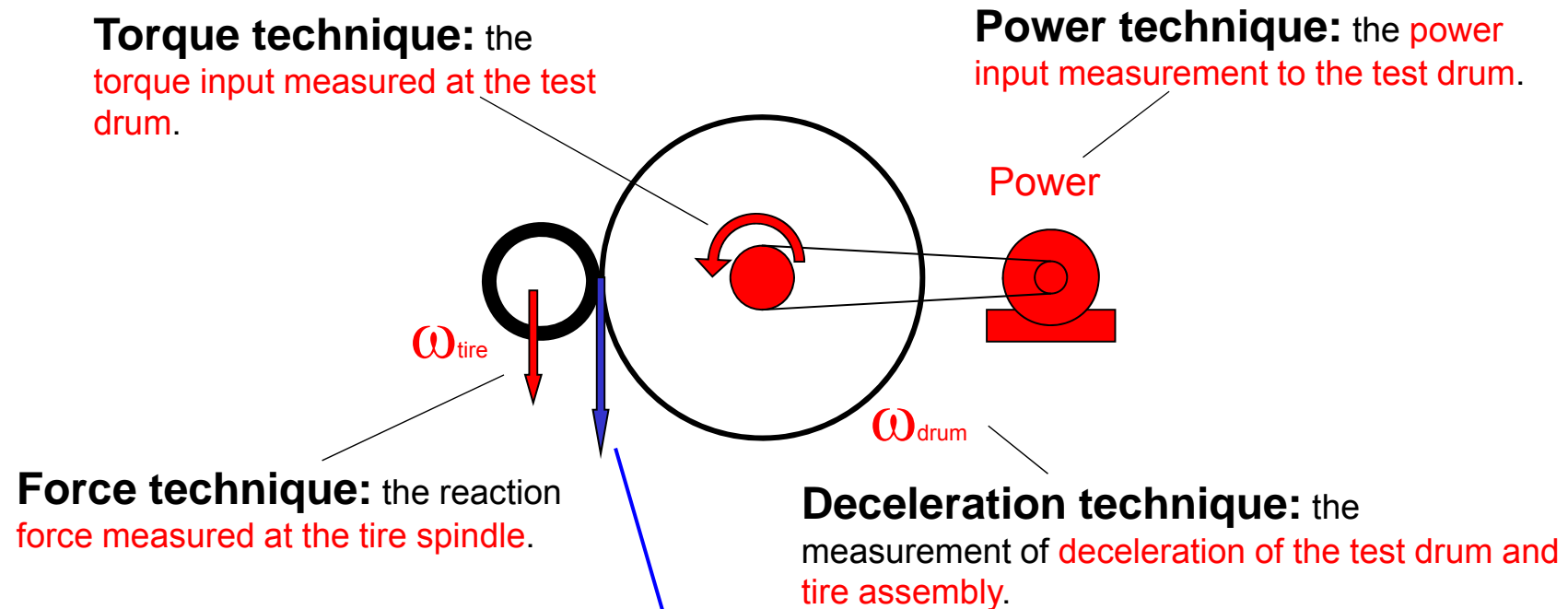
Pneumatic tyres as we know them today need the rubber materials and deformation to generate the required grip between vehicle and road surface, to give vehicle comfort and generate low rolling noise.



## Rolling Resistance measuring methods

The following alternative measurement techniques for data acquisition are given in International Standards. The choice of an individual technique is left to the tester.

**The same phenomenon is measured, at different points of the testing machine.**



**For each technique, the test measurements are converted to a force acting at the tire/drum interface, which is the blue arrow, always EQUIVALENT.**



## Using the same method on different machines

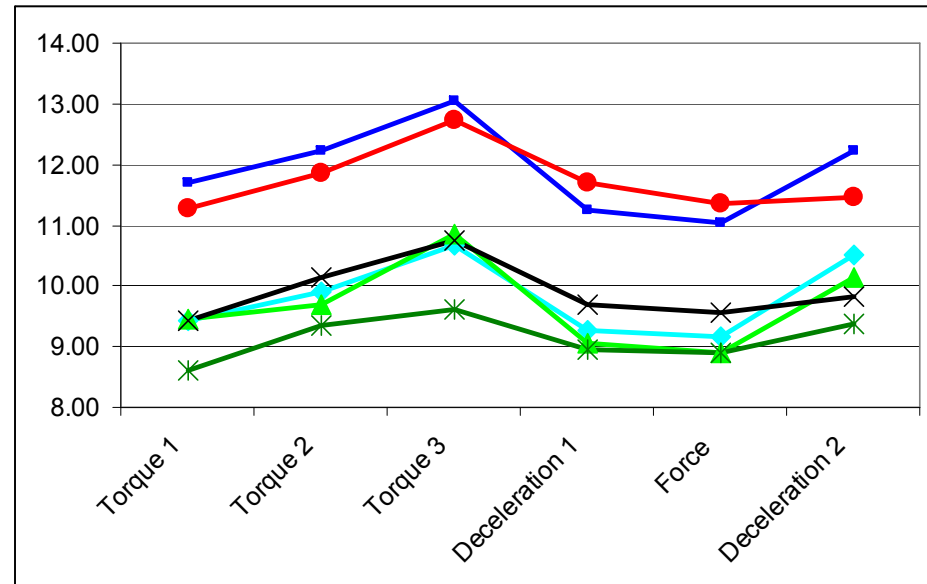
### Example from a round-robin test:

6 identical tyres of different sizes were measured on 6 machines using different measuring techniques:

M/C #1, M/C #2, M/C #3: **Torque**

M/C #4 and M/C #6: **Deceleration**

M/C #5: **Force**



Average values: **9.99** **10.53** **11.27** **9.99** **9.82** **10.59**

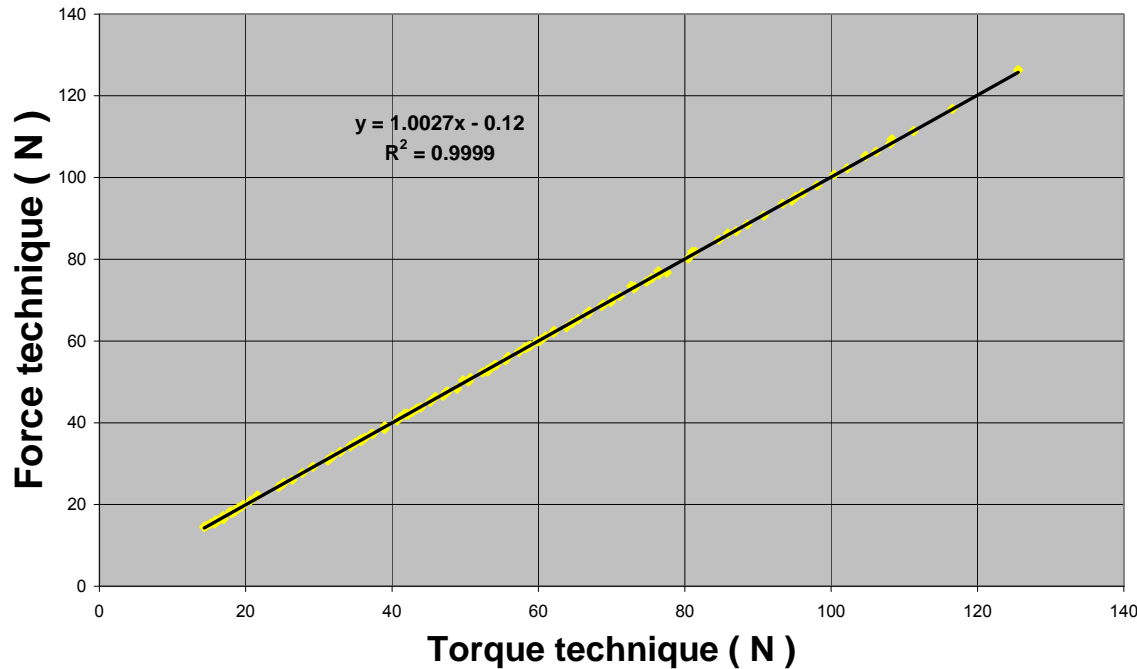
## Using the same method does not reduce variations between machines.

(see values marked blue for torque and values marked red for deceleration)



## Using different methods on the same machine

Force and Torque technique, measured on the identical machine




- Using different methods gives the same results on the same machine.
- The 4 measuring techniques are based on valid physical principles and all of them should be kept.



# Rolling Resistance measuring methods

## The EC rates all 4 measurement techniques as scientifically equivalent:

 EUROPEAN COMMISSION  
ENTERPRISE AND INDUSTRY DIRECTORATE-GENERAL  
Regulatory policy  
Notification of technical regulations

19 AOUT 2009

Brussels,  
ENTR/C/3 BH/NV D(2009) 27011

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**Number of pages:** 1 + 2

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**Subject:** G/TBT/N/USA/471 - Tire Fuel Efficiency Consumer Information Program - EC comments.

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1. The EC notes that the draft US regulation only recognises two of the four test methods specified in ISO 28580, namely the force and the torque methods. The non-recognition of the other two test methods, the deceleration and power methods, is being justified because the National Highway Traffic Safety Administration (NHTSA) in the US does not have the appropriate machines to conduct the tests. However, the EC is of the opinion that all four test methods are scientifically equivalent. Moreover, in Europe most machines are designed for the two test methods that the USA does not intend to recognise. The EC is of the opinion that this will compel EU manufacturers to re-test their tyres in the USA. As a consequence, this would mean higher costs, delays and above all logistical problems in cases where the four methods would not be considered equivalent. In the EC's view, therefore, the US justification is not acceptable and not in line with Articles 2.2 and 5.1.2 of the Agreement on Technical Barriers to Trade.

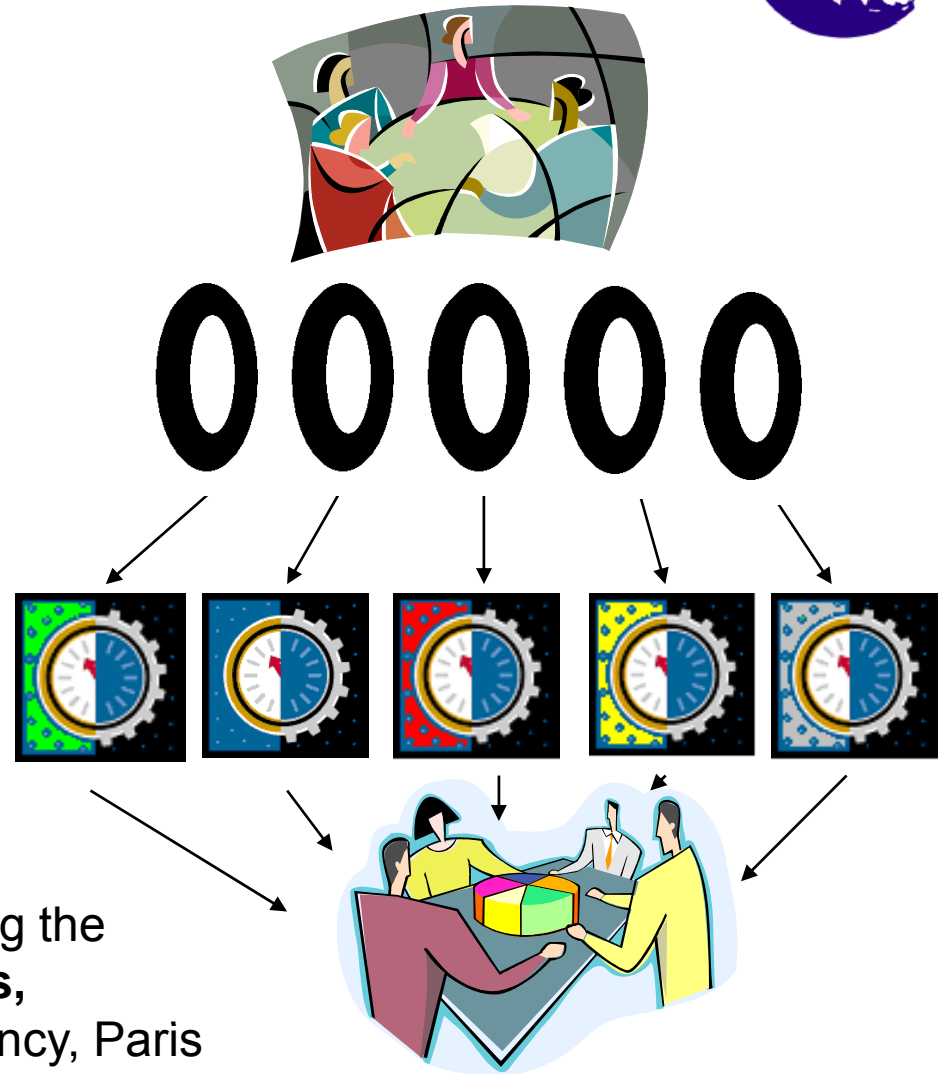
Most importantly, the EC would like to remind the US authorities that the technical regulations under the Agreement of 1958 of the United Nations Economic Commission for Europe ("UNECE") constitute international standards in the sense of the WTO Agreement on Technical Barriers to Trade ("TBT Agreement"), and, moreover, UNECE WP29 is in the process of preparing legislation, which is expected to recognise the four test methods specified in ISO 28580. Consequently, as the US draft in its present state does not recognise all these four test methods, it could infringe the Agreement on Technical Barriers to Trade, Article 2.4, which lays down that where technical regulations are required and relevant international standards exist or their completion is imminent, Members shall use them for their legislation. So far, the US has not presented any justification of why these four tests would be ineffective or inappropriate to fulfil the legitimate objective pursued in this case.



# Calibration of RR machines

Round Robin Test procedure done by ETRTO members:

- Choice of 14 selected tyre types.
- For each tyre type, selection of tyres of the same batch with very close RR values.
- Dispatch of one tyre to each of the 5 participating lab.
- Measurement by each lab according to the method.
- Statistical analysis.

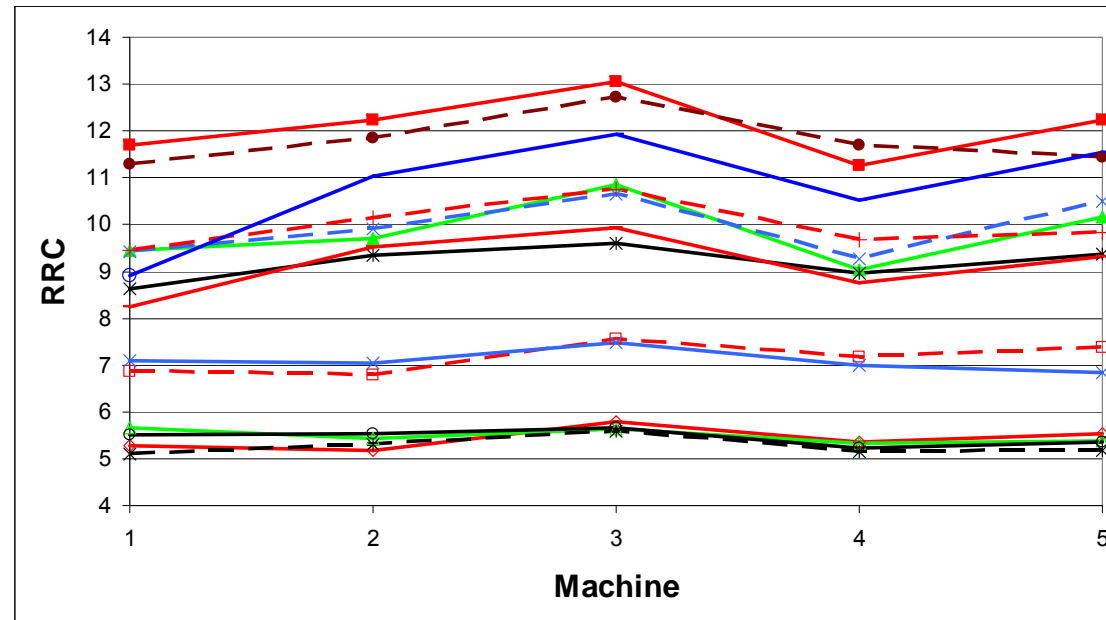


Results of this study were presented during the **IEA workshop on Energy Efficient Tyres**, 15-16 Nov, 2005 International Energy Agency, Paris



## Calibration of RR machines

Results of the round robin study:



Average values of the results of the 14 identical tyres measured by each Lab:

**8.01      8.50      9.09      8.19      8.58**

Machine 3 gives higher values than the others and machines 1 and 4 give lower values. Differences among machines exceed 1 N/kN.

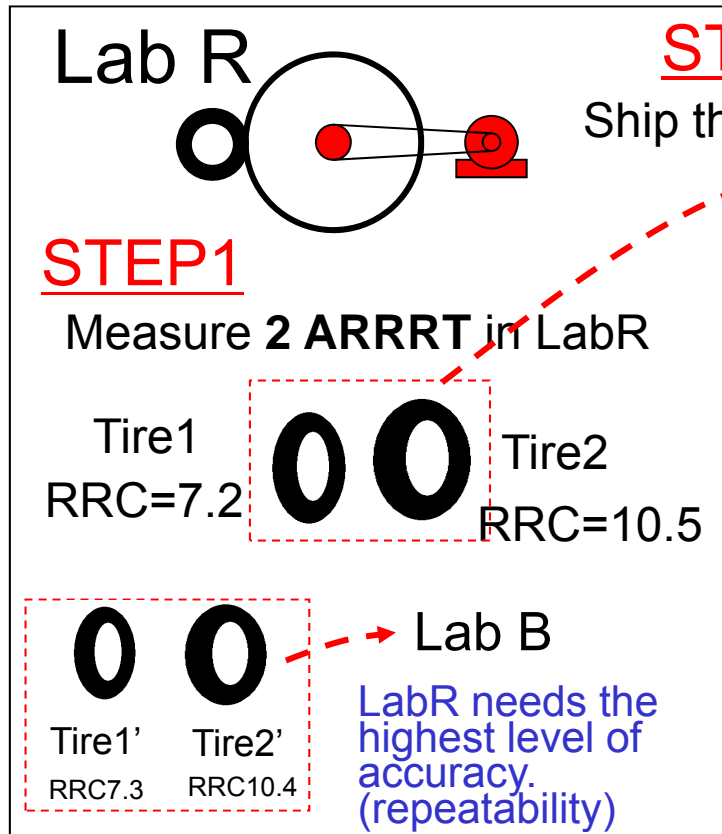
**A calibration is necessary to get comparable values.**

NB: Within its recent NPRM on "Tire Fuel Efficiency Consumer Information Program", the NHTSA recommended the use of ISO 28580 as "the ISO 28580 test method is unique in that it specifies a procedure to correlate results between laboratories and test equipment, which our Research shows is a significant source of variation." (Federal Register / Vol. 74, No. 118 / Monday, June 22, 2009 / Proposed Rules ).

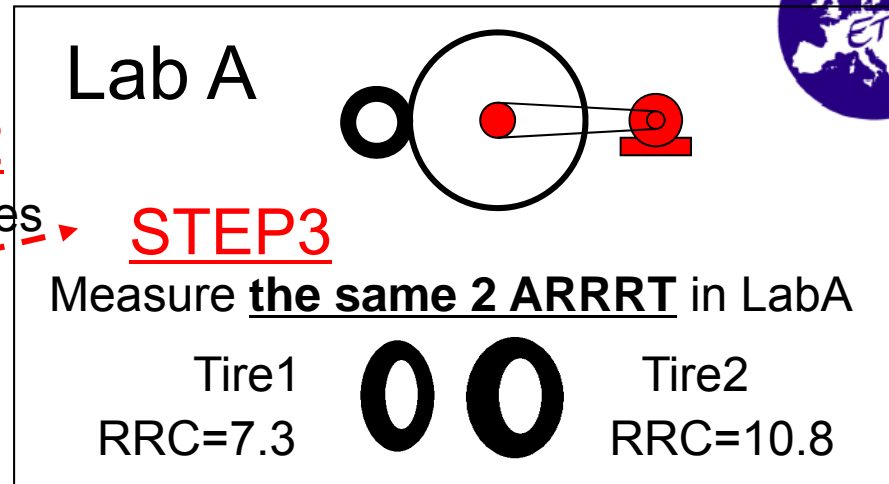




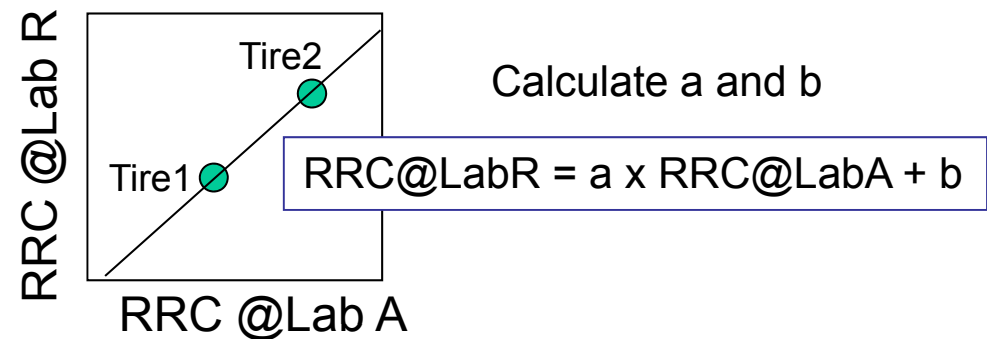
## Concept of ISO 28580



**STEP2**  
Ship the 2 tires



**STEP4** Set up the calibration formula for Lab A



**STEP5** LabA can measure any tires for TA purpose.

Measured RRC is converted to LabR scale with calibration formula.

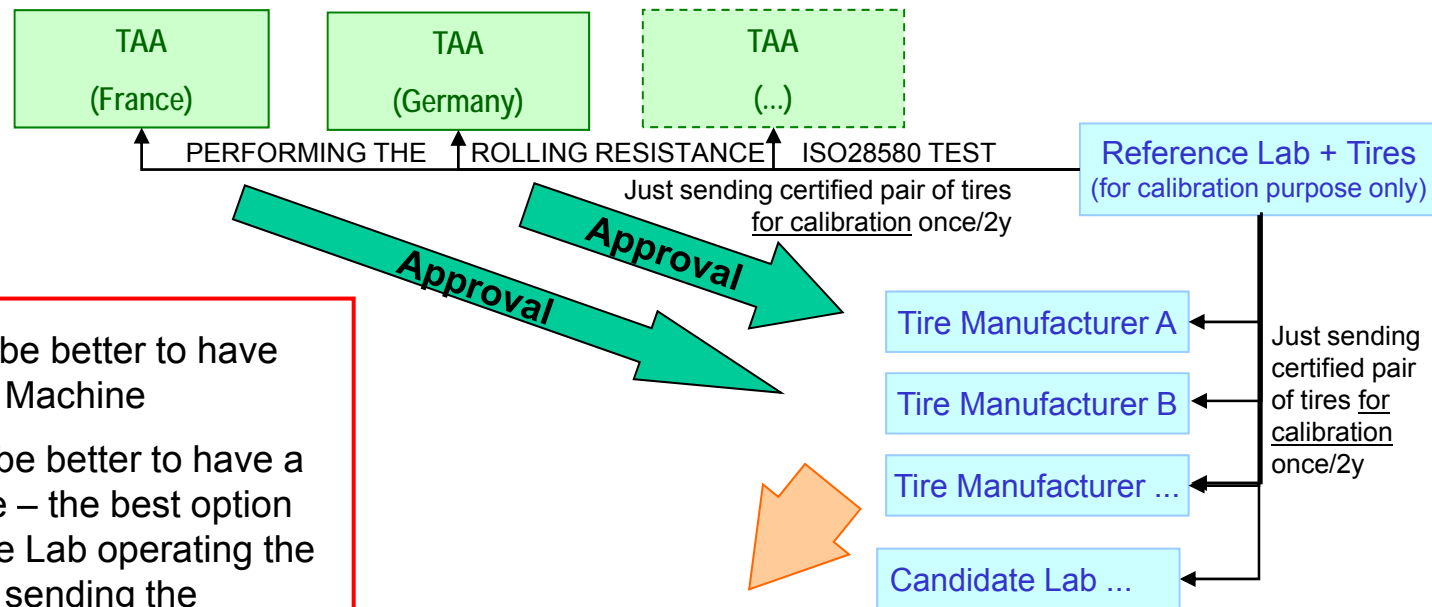
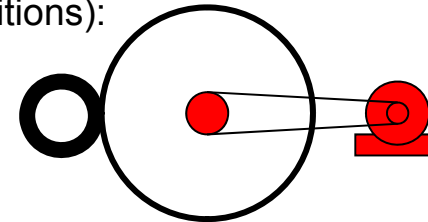
(ARRRT = Alignment Reference Rolling Resistance Tire. Tire1 & Tire2 must have 3N/kN difference.)



To have reliable results, all Candidate Machines must measure almost the same value for any given tyre, with a good repeatability.

**Repeatability** is assured by ISO 28580 (Clause 10 - Conditions):

- Reference Lab Machine       $\sigma_m \leq 0,050$  N/kN
- Candidate Machine (LI  $\leq 121$ )       $\sigma_m \leq 0,075$  N/kN
- Candidate Machine (LI  $> 121$ )       $\sigma_m \leq 0,060$  N/kN



**Accuracy:** it would be better to have only one Reference Machine

**Logistics:** it would be better to have a “one way” exchange – the best option would be to have the Lab operating the Reference Machine sending the couples of tyres already measured, with “certified” values.

**Homologated tyres with fully harmonised values on all CP countries market**



## Calibration of RR machines in ISO 28580

- ISO 28580 will be the RR test method in UNECE R117 (also in other European regulations like R692\_2008, motor vehicle emissions Euro5/6).
- ISO 28580 will probably be used on a global basis (EU, JP, US) and may support different regulatory applications.
- The ISO 28580 Reference Laboratory can be every organization operating a Rolling Resistance Test Machine and complying with all requirements of ISO 28580.
- The choice of an appropriate Reference Laboratory is very important.
- The Reference Laboratory question is under discussion in the ISO TC31 WG6.



**Questions raised during GRB meeting July 23:**

**2.1 (g), Type of tire definition:** “...The tread pattern (except in case of tyre submitted for approval of rolling resistance approval)...”.

If the same green tyre will receive different tread patterns, the tyre RR will not change as the main contributors to RR ( tread compound, volume..) remain the same.

**Example:**

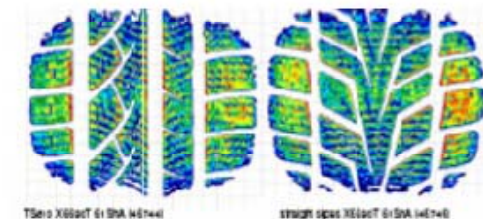
Same tyre construction, molded with 2 different tread patterns.

**RR is practically the same.**



	1 Contl 46744	2 Contl 46746 straight sipes
205/55 R16 - moulded	TS910 Korbach	9005.02.01
Compound:	X6590T	<
Shore-A	61	61

Rolling Resistance	100	99,8
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## Questions raised during GRB meeting July 23:

**2.18.3, New test tyre:** *“Tyre which has not been previously used in a rolling deflected test that raises its temperature above that generated in RR tests, and which has not previously been exposed to a temperature above 40°C”.*

This definition will reduce potential data variation and dispersion due to tire aging effects, The technical experts of the ISO workgroup added this new definition, especially for users of the standard that are not so familiar with such effects.

### **8.4, COP allowance of 0.3 N/kN:**

A COP allowance is a well known, general practice and is well established in regulations. The COP allowance included in the R117 proposal is 0.3 N/kN. This value was determined by the ETRTO members based on data of dispersion of RR in tyre mass production.

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# Back - Up



From ETRTO presentation to IEA Nov 2005.

NB 1: There were 14 tyres sizes instead of 15 because 145/70R13 was removed (could not be measured by Machine 3).

NB 2: Results were presented to IEA workshop:

**Energy Efficient Tyres:**

**Improving the On-Road Performance of Motor Vehicles**

**15-16 November, 2005**

**International Energy Agency, Paris**



# Round Robin Test Results.

- Fifteen tyre types were commonly agreed between the five participating member companies :

**PC Tyres**

	<b>Lmeas=80% LI (daN)</b>	<b>Pmeas (kPa)</b>	<b>OD (cm)</b>
145/70R13	271	210	53.4
165/65R14	343	210	57.0
205/55R16	483	210	63.2
195/65R15	483	210	63.5
245/45R18	557	210	67.7
225/60R17	608	210	70.2
235/65R17 M+S	706	210	73.8

**C tyres**

175/65R14	500	375	58.4
225/65R16	934	475	69.8

**CV Tyres**

205/65R17.5	1459	850	71.1
215/75R17.5	1418	700	76.7
265/70R19.5	2272	850	86.7
315/70R22.5	3127	900	101.4
385/65R22.5	3752	900	107.2
12.00R24	3752	850	122.6



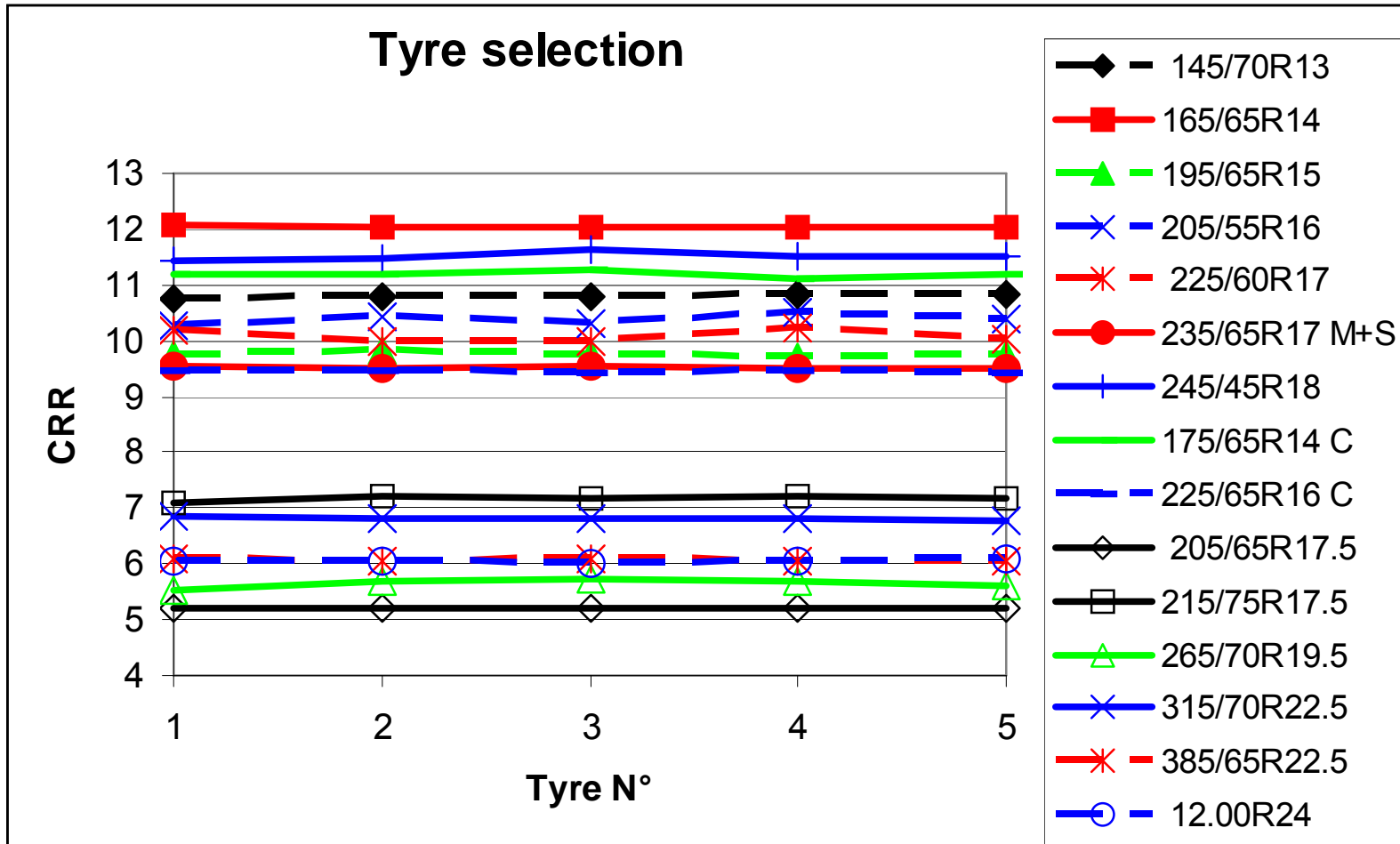


# Round Robin Test Results.

- From each type, 5 tyres were selected, with a very similar RR level. The tyres were measured by each company with the retained method, within its own laboratory.

	1	2	3	4	5	Mean	Std Dev	Ratio
145/70R13	10.77	10.79	10.81	10.84	10.83	10.81	0.029	0.26%
165/65R14	12.08	12.05	12.05	12.02	12.02	12.04	0.025	0.21%
195/65R15	9.74	9.84	9.76	9.70	9.74	9.76	0.052	0.53%
205/55R16	10.27	10.43	10.29	10.51	10.37	10.37	0.099	0.96%
225/60R17	10.18	10.00	9.97	10.25	10.03	10.09	0.122	1.21%
235/65R17 M+S	9.54	9.52	9.54	9.52	9.49	9.52	0.020	0.22%
245/45R18	11.44	11.46	11.62	11.53	11.53	11.52	0.071	0.62%
175/65R14 C	11.20	11.20	11.28	11.12	11.19	11.20	0.057	0.51%
225/65R16 C	9.45	9.48	9.44	9.48	9.41	9.45	0.029	0.31%
205/65R17.5	5.20	5.20	5.19	5.20	5.20	5.20	0.004	0.09%
215/75R17.5	7.09	7.23	7.18	7.21	7.19	7.18	0.054	0.75%
265/70R19.5	5.52	5.68	5.73	5.68	5.59	5.64	0.084	1.49%
315/70R22.5	6.85	6.81	6.80	6.82	6.79	6.81	0.023	0.34%
385/65R22.5	6.10	6.03	6.08	6.03	6.03	6.05	0.034	0.56%
12.00R24	6.05	6.03	6.01	6.05	6.09	6.05	0.027	0.45%





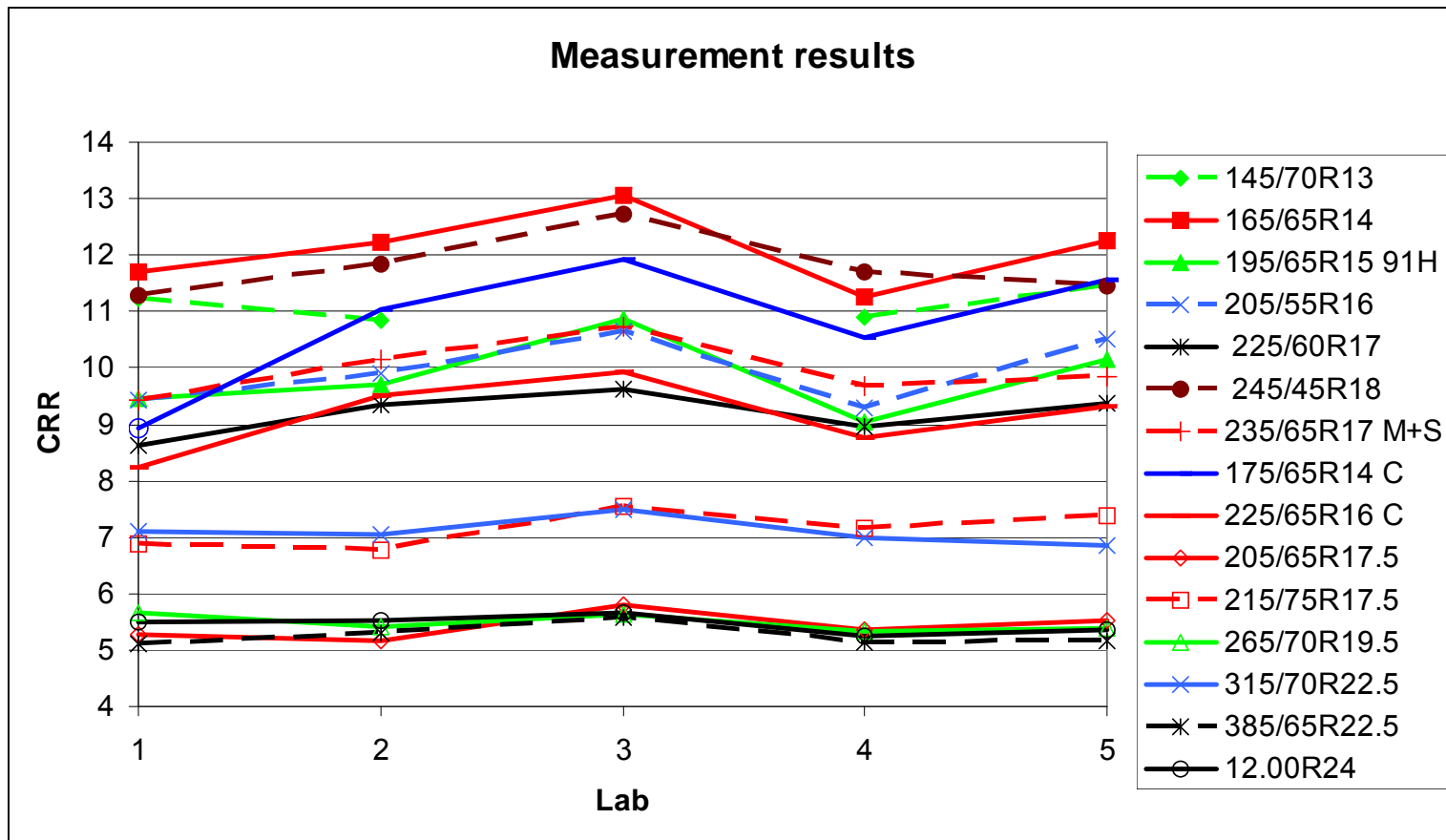


# Round Robin Test Results.

- Results for the RR Coefficients, with a correction to 25°C and drum diameter of 2m.

	1	2	3	4	5
145/70R13	11.23	10.84		10.90	11.45
165/65R14	11.70	12.23	13.05	11.26	12.24
195/65R15	9.45	9.70	10.86	9.04	10.15
205/55R16	9.42	9.90	10.66	9.28	10.50
225/60R17	8.62	9.34	9.61	8.96	9.38
235/65R17 M+S	9.44	10.15	10.74	9.69	9.83
245/45R18	11.28	11.85	12.73	11.69	11.45
175/65R14 C	8.92	11.04	11.93	10.52	11.55
225/65R16 C	8.25	9.51	9.93	8.75	9.31
205/65R17.5	5.27	5.17	5.79	5.35	5.53
215/75R17.5	6.87	6.78	7.56	7.16	7.37
265/70R19.5	5.67	5.42	5.64	5.33	5.39
315/70R22.5	7.10	7.04	7.48	6.99	6.85
385/65R22.5	5.10	5.31	5.58	5.14	5.17
12.00R24	5.50	5.53	5.65	5.24	5.35

The process of tyre making and RR measuring leads to **low dispersion**.  
 The second measurement did **not** induce substantial **tyre evolution**.  
**Systematic differences** appeared (e.g. lab #3 systematically higher values) and the WG was led to perform a statistical **alignment procedure**.



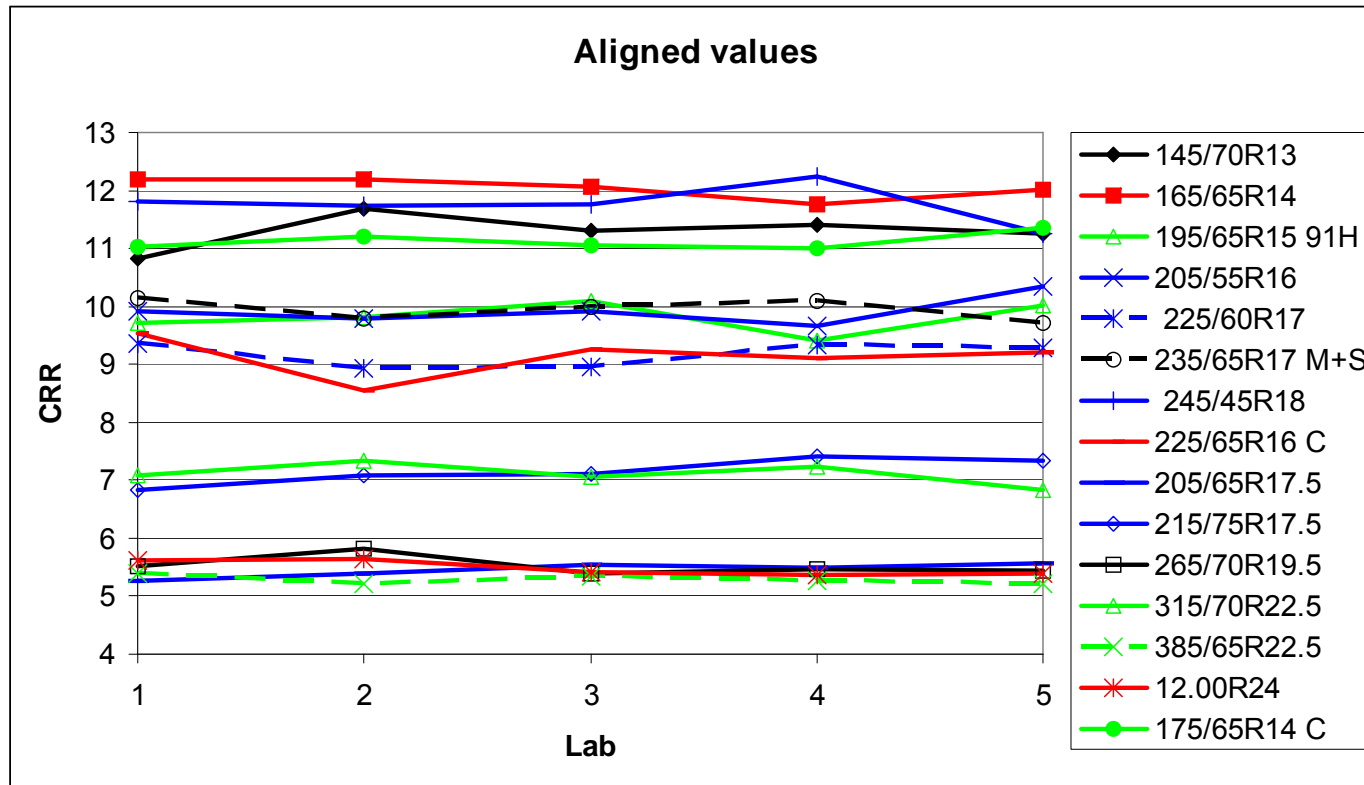


# Round Robin Test Results.

- Aligned values.

mean		Aligned values					Differences					
		1	2	3	4	5	1	2	3	4	5	Mean
11.11	145/70R13	10.83	11.69	11.30	11.40	11.26	2.46%	5.25%	1.75%	2.60%	1.37%	2.68%
12.10	165/65R14	12.20	12.18	12.05	11.77	12.02	0.87%	0.74%	0.35%	2.69%	0.61%	1.05%
9.84	195/65R15	9.71	9.81	10.09	9.42	10.01	1.34%	0.32%	2.50%	4.31%	1.73%	2.04%
9.95	205/55R16	9.91	9.78	9.91	9.67	10.35	0.44%	1.75%	0.47%	2.86%	3.97%	1.90%
9.18	225/60R17	9.36	8.93	8.96	9.33	9.27	1.89%	2.72%	2.38%	1.58%	0.98%	1.91%
9.97	235/65R17	10.15	9.80	9.98	10.10	9.71	1.78%	1.71%	0.12%	1.30%	2.63%	1.51%
11.80	245/45R18	11.82	11.74	11.77	12.23	11.26	0.20%	0.50%	0.29%	3.68%	4.57%	1.85%
9.15	225/65R16 C	9.53	8.54	9.25	9.10	9.20	4.12%	6.64%	1.06%	0.51%	0.59%	2.59%
5.42	205/65R17.5	5.26	5.40	5.53	5.48	5.57	3.07%	0.46%	2.06%	1.10%	2.69%	1.87%
7.15	215/75R17.5	6.84	7.09	7.12	7.42	7.34	4.34%	0.86%	0.41%	3.75%	2.64%	2.40%
5.49	265/70R19.5	5.51	5.82	5.40	5.47	5.43	0.26%	5.96%	1.75%	0.42%	1.08%	1.89%
7.09	315/70R22.5	7.09	7.33	7.05	7.23	6.84	0.02%	3.34%	0.59%	2.01%	3.60%	1.91%
5.26	385/65R22.5	5.39	5.22	5.35	5.26	5.22	2.52%	0.82%	1.62%	0.01%	0.76%	1.15%
5.45	12.00R24	5.61	5.64	5.41	5.36	5.39	2.91%	3.40%	0.87%	1.67%	1.10%	1.99%
11.26	175/65R14 C	11.03	11.20	11.05	10.99	11.36	2.05%	0.55%	1.92%	2.40%	0.87%	1.56%





8.68    8.68    8.68    8.68    8.68