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SHAKTI
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Standards and labelling programme for passenger car tyres

April 2018

An initiative supported by

Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency and sustainable transport solutions.

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Acknowledgements

The success of this project was a result of a series of intermediate steps and activities, a few straightforward and few complex, which were imperative for arriving at the final outcome. We are privileged to have received support from stakeholders in the Indian tyre industry in terms of direction and, in a few instances, technical guidance throughout the duration of this project.

We would first like to thank Shakti Sustainable Energy Foundation (SSEF) for providing us with the opportunity to work on this important and prestigious assignment. We have no doubt that the results of this study will support the tyre industry in introducing policy options for improving the fuel efficiency of tyres in the countries.

We would like to acknowledge the support received from the Indian Rubber Manufacturers' Research Association (IRMRA), especially in relaying the technical details of (rolling resistance coefficient) RRC and the testing procedures prescribed in United Nations Economic Commission for Europe Regulation 117.02 (UNECE R117.02.) Without their help, identification of the appropriate tyre sample set and subsequent testing for RRC as per the internationally recommended test procedure would not be possible.

The role of the International Centre for Automotive Technology (ICAT) was also substantial during the course of the project. Their technical knowledge on and excellent facilities for wet grip testing of tyres facilitated the generation of wet grip results for sample tyres—an activity that was carried out in India for the first time. We hope that this experience will lead to further testing of tyres for wet grip for the development of standards.

We would also like to thank other stakeholders such as the transport engineering department (TED) 7 committee of bureau of Indian standards (BIS), the national automotive test tracks (NATRAX), automotive tyres manufacturers association (ATMA), tyre manufacturers and test laboratories such as automotive research association of India (ARAI), central institute of road transport (CIRT) and vehicle research and development establishment (VRDE) for their invaluable inputs in this study. The study could not have been completed without their support.

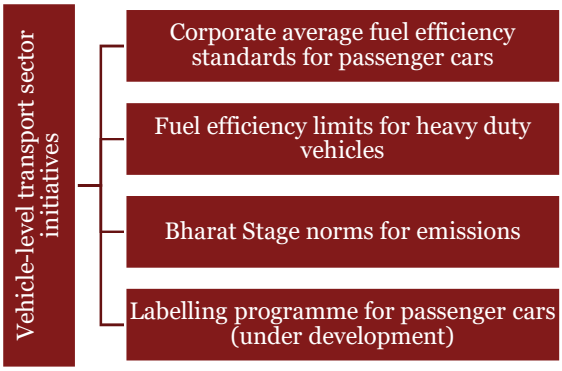
Introduction

Amidst growing concerns around rising global temperatures and instances of extreme weather and climate change, governments across the world have taken initiatives to introduce efficiency in their net energy use. These initiatives attempt to promote efficient use of energy (or fuel) across all sectors, including transport, power and industries.

For countries such as India, where the fiscal deficit includes mainly petroleum imports, the introduction of policies to improve efficiency in the transport sector (termed as 'fuel efficiency') has an added advantage—that is, reduction in import burden on the fiscal budget. Given the frequent and unpredictable volatility in petroleum prices, any relative reduction in fuel use reduces the country's vulnerability on price changes and supports its mandate of energy security.

Fuel efficiency mandate of the transport sector

In light of these advantages, the Government of India has introduced several initiatives in the transport sector with an aim to reduce the intensity of emissions from vehicles and improve fuel efficiency. These initiatives target the overall vehicle and not specific vehicular components such as engines /transmission.



Recent fuel efficiency initiatives

Over the last six years, the government has taken several steps to promote electric mobility; one among them is the introduction of the recently launched FAME (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India) pilot scheme. Through the landmark 'FAME India' initiative, end users are provided a substantial subsidy for the purchase of electric and hybrid vehicles. The Central Government has also declared its target to have only electric vehicles on Indian roads by 2030.

Given the wide range of initiatives and a continuous effort on the part of the government to expand and deepen these initiatives on fuel efficiency, the Indian automotive sector is set to undergo a vehicular efficiency revolution of sorts when these policies come into force. However, these policies are likely to put pressure on the automotive industry, especially vehicle manufacturers who will need to improve the overall efficiency of their vehicle fleets.

Improving vehicular fuel efficiency

The efficiency in a motor vehicle with respect to fuel consumption is subject to several design parameters. Although the manufacturers are considering various engine, transmission and overall vehicle-level technology options such as the use of turbocharging and intercooling, development of lean burn engine, variable valve timing, weight reduction, vehicle aerodynamics, improvement of thermal management, downsizing of engines, dual clutch transmission, etc., for fuel efficiency and vehicle performance improvements, however, some of these options also require longer lead time for larger implementation as the cost also becomes a controlling factor.

The options available to manufacturers in terms of advances in specific component-level efficiency also have the potential to contribute significant reduction in fuel consumption and are expected to be the focus in the coming decade as these technology options are proven to be simple and easy to introduce on a large scale.

One of the key component-level options is the introduction of low rolling resistance (RR) tyres. **Tyres,** as a component, have been identified to have a huge potential for improving fuel efficiency of vehicles.[1] This technology is proven to work and is

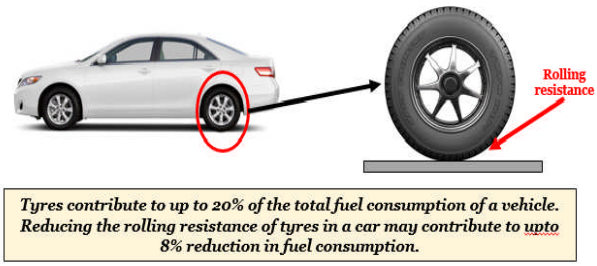
[1] 54.5 MPG and beyond: New tire technology pumps up fuel savings. http://energy.gov/articles/545-mpg-and-beyond-new-tire-technology-pumps-fuel-savings

being followed in other countries. Further, tyre manufacturers in India already have the capability to produce such tyres as there are already a few low RR tyres available in the market. This subject (tyres) has been the focus of this study.

Tyres an as option for fuel efficiency

'Tyres, on account of their rolling resistance, account for approximately 20% of vehicular fuel consumption.'[2]

RR is a measure of the energy dissipated as heat because of the rolling of a tyre. A reduction in RR in tyres would therefore contribute significantly to the fuel efficiency thrust of the road transport sector and consequently to the reduction of greenhouse gas (GHG) emissions intensity. Having identified this potential, governments of several countries have implemented policy measures, seeking to promote manufacturers to manufacture and consumers to purchase fuel-efficient tyres.



Rolling resistance illustration[3]

The frontrunners in developing labelling programmes for passenger car tyres considering rolling resistance coefficient (RRC) as an indicator for fuel efficiency include the European Union (EU), Japan and South Korea.

The programmes developed in the EU, Japan and South Korea are based on UNECE R117.02 (globally accepted standard), the regulation on 'tyres, rolling resistance, rolling noise and wet grip', which described the test procedures to calculate tyre RRC, wet grip performance (G) and rolling noise performance, and sets requirements for these parameters.

The European case example

The European Commission passed the tyre labelling regulation 1222/2009 with a goal to improve the safety, economic and environmental efficiency of road transport by promoting fuel-efficient and safe tyres with low noise levels. The label specifications are aligned with the standards specified in UNECE R-117 and were made mandatory from 2012.

A review (impact assessment) study on the tyre labelling regulation conducted in March 2016 suggests that the regulation '***has been able to transform the market in a positive direction from 2013 to 2015, although the positive tendency is less obvious for external rolling noise than for fuel efficiency and wet grip'.***[4]

The study purchased market data from two major EU tyre databases—that is, TOL[5] (Germany) and VACO[6] (Holland)—and supplemented it with information from industry associations to create a tyre stock model for use in scenario calculations. Analysis of the market data shows that the Tyre Labelling Regulation has driven an increased R&D and technology innovation effort, resulting in increased wet grip performance of tyres, as well as the optimisation of fuel efficiency, leading to decreased fuel consumption.

The report also suggested that **RR change rates are likely to increase during the coming years if the implementation is continuously supported.**

Surveys were also prepared and conducted as a part of the study to assess the tyre buying behaviour of the end users, end user awareness of the Tyre Labelling Scheme, and the need for further information on the label.[7] The C1 tyres (passenger car tyres in the EU) end user survey showed that around half of the private car owners in the surveyed countries are aware of the tyre label.

The findings of the report show that **appropriate policy measures for tyres can be successful in improving RR performance of tyres** without deteriorating their wet grip performance.

Existing regulations applicable to tyres in India

Since 2010, all tyres manufactured and sold in India are required to comply with the specifications mentioned in IS 15627, IS 15633 and IS 15636 for two- and three-wheeled motor vehicles, passenger car vehicles and commercial vehicles respectively.

[2] The European Commission, Impact Assessment Study on Possible Energy Labelling of Tyres, July 2008
[3] The European Commission, Impact Assessment Study on Possible Energy Labelling of Tyres, July 2008
[4] Review study on the Regulation (EC) No 1222/2009 on the labelling of tyres, March 2016
[5] Tyres online and Energy GmbH
[6] Dutch Tyre and Wheel Trade Association
[7] The surveys were highly focused towards C1 tyres.

The standards mentioned above specify requirements related to safety, durability and dimensions for tyres in India. However, these standards do not specify requirements for performance parameters such as RR, wet grip, external noise, internal noise and braking performance. This suggests that introducing regulations for RR for tyres can result in considerable fuel savings in India.

Developments towards the introduction of RR[8] and wet grip[9] requirements in India

The (transport engineering department) **TED 7 committee** of the Bureau of Indian Standards (BIS), which is responsible for the composition of standards of automotive tyres, tubes and rims, began discussions on the drafting standards for RR and wet grip for tyres in India in 2014. Despite relentless efforts of the committee members and various stakeholders, the presence of several important issues, including test data for tyres for Indian conditions and aligned test facilities has slowed down the progress of development of standards in India.

Specifically, as per the 'Framework for standards and labelling (S&L) tyres in India',[10] the process of developing standards for RR and wet grip faced limitations such as: (i) limited infrastructure for testing of RR and wet grip in India; (ii) need for the alignment of test laboratories for RR testing in India with standard reference laboratories; and (iii) unavailability of data on the Indian tyre market.

However, since then, most of these barriers have already been addressed to some extent, specifically:

- Based on consultation discussions with respective laboratories, test infrastructure for determination of tyre RRC as per ISO 28580 is available with the Indian Rubber Manufacturers' Research Association (IRMRA), and the tyre test trailer for determination of wet grip is available with the International Centre for Automotive Technology (ICAT).
- Officials from IRMRA have informed that they have begun the alignment process, as per ISO 28580, with laboratories in Europe. The process is underway and shall be completed soon. This implies that the issue of variation in RRC value will be addressed.
- Since test infrastructure is now available in India, the generation of data on the Indian tyre market will not prove to be an extravagant task.

Therefore, data on the Indian market, which was a major constraint in India, can now be generated in third-party test agencies. This could facilitate development of standards for tyre RRC and wet grip performance in the country.

Next steps to support stakeholders for the development of standards in India

The next major step towards the development of standards for tyres is to generate data on the Indian tyre market. The most convenient way forward is to conduct tests for RR and wet grip for randomly selected samples from the passenger car segment through the test facilities available with agencies in India.

Once data is generated for the passenger car segment, the TED 7 committee/stakeholders can analyse this data in order to arrive at benchmark values for RRC and wet grip coefficients in the passenger car tyre market.

Objective of this assignment

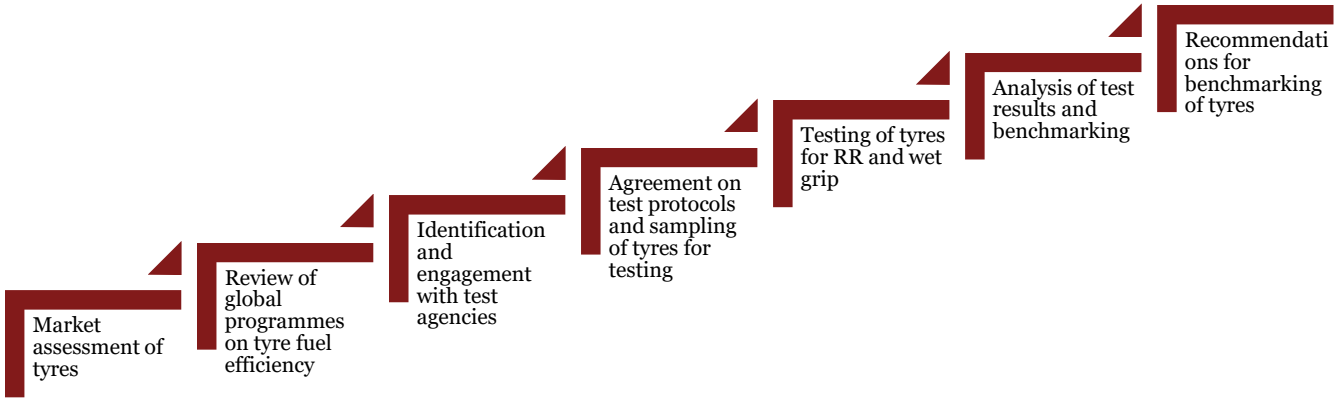
This assignment intends to generate requisite test data for key parameters needed for the assessment of tyre performance. The test data, along with a market-trend analysis and review of international best practices, is used to perform benchmarking of RR and wet grip performance of tyres in India. The findings will be shared with the relevant stakeholders for further pursuit in this initiative. The assignment is focused on passenger cars tyres for which the vehicle standards are at an advanced stage of implementation.

[8] RR is a measure of the energy dissipated as heat because of rolling of the tyre. A reduction in RR of tyres would therefore contribute significantly to fuel efficiency. RR is measured in terms of RRC.

[9] Wet grip refers to the safety performance of tyres. It defines the ability of a tyre to brake on a wet road. The wet grip of a tyre is judged by calculating its wet grip index (G).

[10] Framework for S&L of tyres in India. Study by SSEF, September 2016

Approach



This section describes the approach adopted to achieve the intended outputs of the assignment.

Market assessment

The approach for market analysis involved conducting three mutually exclusive and exhaustive activities: review of existing reports on the Indian tyre market, interaction with key stakeholders at all levels, such as IRMRA, ICAT, tyre manufacturers etc., and conducting independent assessment of tyres available in the market. A database of specifications of 694 passenger car tyre models was formulated.

Review of global programmes on tyre fuel efficiency

To further understand the potential for fuel efficiency through tyres, a detailed review of global programmes focusing on tyre fuel efficiency was undertaken. The labelling programme in the EU and other countries and the regulation UNECE R117.02 was a core focus of this topic.

Identification and engagement with test agencies

Test agencies such as IRMRA and ICAT, which have the facilities to test RR performance and wet grip performance of passenger car tyres respectively, were engaged for the testing of representative samples of passenger car tyres.

Agreement on test protocol and sampling of tyres for testing

In consultation with test agencies, the procedure for testing of RR and wet grip performance of passenger car tyres, as defined in ISO 28580 and UNECE R117, were discussed and finalised. The exercise also focused on the selection of an appropriate sample tyre set for performance testing. Insights from the market assessment exercise were used to identify an appropriate tyre sample set.

The selected sample set was then tested for RR and wet grip performance at the designated testing agencies.

Testing of passenger car tyres for RR and wet grip performance

Two sets of tyre samples were purchased for the testing exercise. One for RR testing and one for wet grip. The tyre samples were purchased through the official dealer network and transported to the lab's premises.

Testing for the determination of RR was performed at IRMRA's premises in Thane. Testing for the determination of wet grip was performed in Indore at NATRAX's facilities by the ICAT. The test procedures followed were as mentioned in UNECE R117.02 for both tests. The ICAT arranged for the transportation of trailer and SRTT tyres to Indore.

Analysis of test results and performance benchmarking

The RR and wet grip test results were analysed using standard techniques to identify the existing situation of the Indian market in terms of RR and wet grip, investigate the relationships among various tyre parameters, and assess the benchmark values of RRC and wet grip index for the Indian market.

Final recommendations

A set of recommendations was produced on the basis of the results of the analysis conducted at the previous stage. Each option was assessed on the basis of its merits, advantages of adoption and key challenges likely to be faced. Finally, a set of next actions are proposed for supporting the stakeholders in the formulation of fuel efficiency programmes for tyres.

Overview of the tyre market in India

The tyre industry in India is highly organised and is dominated by few major players (approximately 30), as a result of the capital intensive nature and competitiveness of the industry. Of the 30, 11 key players are registered with the Automotive Tyre Manufacturers Association (ATMA). These players include, Apollo Tyres Ltd., Birla Tyres, Ceat Ltd., Bridgestone India Pvt. Ltd., Continental India Ltd., Goodyear India Ltd., JK Tyre & Industries Ltd., Michelin India Pvt. Ltd., MRF Ltd., TVS Srichakra Ltd., and Yokohama India. As per ATMA, these companies account for more than 90% of the total industry size in value terms.

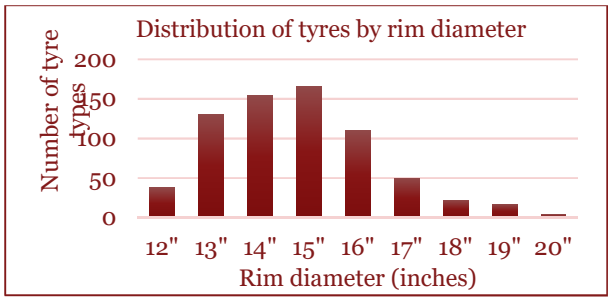
Tyres sold in the market are marked with a specific code/configuration that describes the tyre's size, construction type, load index and speed limit rating:

(section width in mm)
/(aspect ratio) (construction type)(rim diameter in inches)

For example, a code of 175/65 R15 indicates that the tyre has a section width of 175 mm, aspect ratio of 65 and radial construction with a rim diameter of 15".

The passenger car tyre market

To assess the passenger car tyre market in India, a database comprising 694 tyre models from seven major manufacturers was formed by the project team. An illustrative representation of tyres by rim diameter is shown below:



Distribution of tyre types by rim diameter

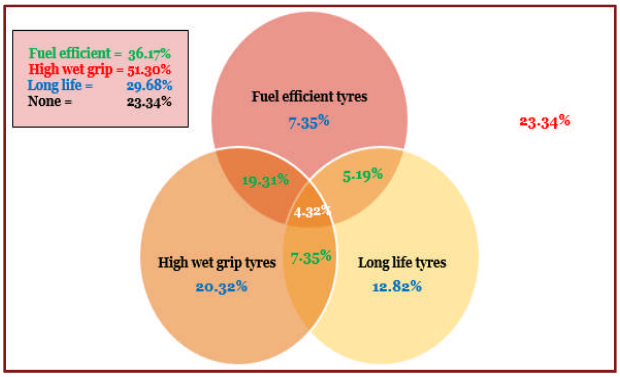
Like the overall tyre industry, the passenger car tyre segment is also closely linked with the passenger car market in India. The research conducted and inputs from stakeholders reveal that passenger cars with a lower weight category dominate the market in terms of total sales. Likewise, the market for tyres of low rim sizes such as 12", 13", 14" and 15" is more as the vehicles equipped with such tyres have a larger market base. The passenger car tyre market is dominated by tyres of rim sizes in the range 12" to 15" followed by tyres of size 16" and 17" which are mostly used in mid-segment cars. Tyres of higher rim diameters—that is, 18" to 20" are for high-end luxury cars and therefore represent a small market share.

Tyre branding

A tyre's characteristics are influenced by factors such as tread pattern and tyre material. These factors are common for a specific brand of tyres sold. Tyre manufacturers specify the characteristics in their advertisements and brochures. These include:

- Fuel efficiency/saving or low RR
- High wet grip or wet braking performance
- High mileage
- Durability, high load carrying capacity, etc.

The following Venn diagram describes the distribution of characteristics across 694 tyre models (as per the claims made by tyre manufacturers) for which the data was collected.



Distribution of tyre characteristics

Manufacturers of about 35% of all tyre types have claimed that their tyres are fuel efficient. This represents the penetration of fuel-efficient tyres in the Indian market. Also, these fuel-efficient[11] tyre models seem to be available for tyres across all rim diameters.

Unorganised market

Although the passenger car tyre market comprises established players, a small but significant portion of the market is captured by imported unorganised market tyres, which are being fed through cash-driven unorganised channels. These tyres are mostly available in smaller rim sizes such as 12", 13", 14" and 15", and typically cost half in comparison to an average tyre of similar size.

[11] Here, fuel-efficient tyres refer to the tyres with low RRC

Review of global programmes

Several countries have set tyre benchmarks and labelling programmes to raise consumer awareness and promote fuel efficiency in the tyre industry. These include countries in the EU, South Korea and Japan. The programme in the US is yet to be finalised. The programmes in South Korea and Japan are aligned with the limits specified in the UN ECE R-117, the UN regulation setting requirements on fuel efficiency, wet grip and rolling sound emission for tyres.

UNECE R117 was first introduced in 2005, which introduced requirements on the maximum rolling sound emissions of tyres. In 2006, the 01 series amendments to UN ECE R117 added requirements on the minimum wet grip performance of passenger car tyres (C1 tyres). In 2011, the 02 series amendments to UN ECE R117 added requirements on the maximum RR of tyres and increased the stringency of the maximum rolling sound emissions requirements. As per the 02 series amendments, the maximum allowable RRC value for C1 tyres was 12 N/kN from November 2012 (stage 1). Since November 2016, the maximum allowable RRC value for C1 tyres is 10.5 N/kN (stage 2).

Description	Requirements for car tyres	
	Stage 1	Stage 2
Applicability	1 November 2012	1 November 2016
Max. RRC value (unaligned)	12 N/kN	10.5 N/kN
Applicable test procedure	ISO 28580 w/o point 10	

The threshold values of 12 N/kN and 10.5 N/kN were chosen to ensure that the regulation covers the majority of the European passenger car tyre market, which mostly comprises tyres of rim diameters 15" and above.

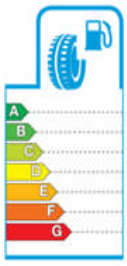
The **regulation UNECE R117 has also set minimum standards for wet grip that must be met** by all tyres that come under the scope of the regulation. The test methods for measuring the three parameters have been specified in the annexures of the regulation. The minimum value of G (wet grip index) that ***tyres of category C1*** must maintain as per the regulation are indicated below.

Tyre category	G
Snow tyre with speed symbol indicating permissible speed ≤160 km/hr	0.9
Snow tyre with speed symbol indicating a maximum permissible speed >160 km/hr	1.0
Normal (regular use) tyre	1.1

The EU tyre labelling programme

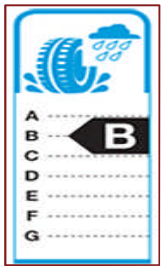
Regulation 1222/2009 establishes a mandatory labelling scheme for tyres sold in the EU. The label is based on three parameters: RRC, wet grip index and noise. The labelling criteria is based on the limits prescribed in UNECE R117.02. **Tyres marked as G** (as per the labelling scheme) **do not conform to the stage 1 requirements, and those marked as F do not conform to the stage 2 requirements.**

EU Regulation 1222/2009 – Tyre fuel efficiency labelling



Fuel efficiency grade for C1 tyres	Range of RRC values (N/kN) Aligned.
A	up to 6.5
B	6.6 to 7.7
C	7.8 to 9
E	9.1 to 10.5
F	10.6 to 12
G	greater than 12

For the EU tyre labelling regulation, the fuel efficiency rating of a tyre is defined using its aligned RRC value. The aligned RRC value is calculated by applying a correction formula to the unaligned RRC value obtained through RR testing.



In addition, the EU tyre labelling regulation has defined a grading scheme for wet grip index for C1 (passenger car tyres), C2 (light commercial vehicle tyres) and C3 (truck and bus tyres). This is illustrated in the following table.

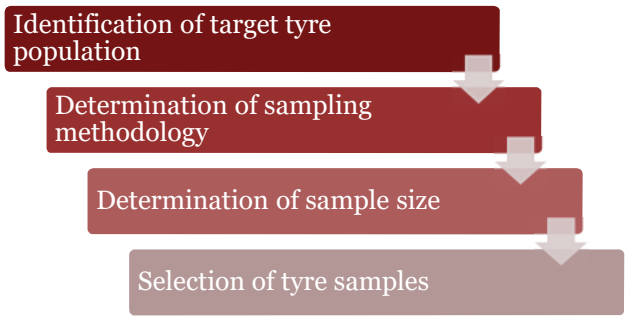
Grading using wet grip index (G)

Class	C1	C2	C3
A	1.55 ≤ G	1.40 ≤ G	1.25 ≤ G
B	1.40 ≤ G ≤ 1.54	1.25 ≤ G ≤ 1.39	1.10 ≤ G ≤ 1.24
C	1.25 ≤ G ≤ 1.39	1.10 ≤ G ≤ 1.24	0.95 ≤ G ≤ 1.09
D		-	0.80 ≤ G ≤ 0.94
E	1.10 ≤ G ≤ 1.24	0.95 ≤ G ≤ 1.09	0.65 ≤ G ≤ 0.79
F	G ≤ 1.09	G ≤ 0.94	G ≤ 0.64

Tyre sampling and testing

An outline of the approach adopted for the selection of the tyre sample set for testing for determination of RRC and wet grip index is discussed in this section.

The principle of **stratified sampling has been adopted** for the selection of tyre samples. Since RRC was the primary characteristic of interest, and it was understood that RRC was highly influenced by rim diameter, strata were formed based on rim diameter.



A sample size of 30 was selected based on the relative population of tyres within each stratum and the budget available for testing for RRC and wet grip index. The sample set also comprised six 'outlier' tyres such as imported tyres, tyres from the unorganised market and tyres not prevalent in the Indian market.

The sample set was selected such that representations from all major rim diameter sizes, section widths, major tyre brands and existing market shares were taken into account. Based on this approach, the final sample set determined for RR and wet grip testing is shown in the following table.

All tyres mentioned in the table were tested for RR. Tyres marked in grey were tested for wet grip as well.

12"	13"	14"	15"	16"	17"
Ceat Milaze TL 135/70 R12	**MRF ZVTS** 145/70 R13	**Pirelli** 185/65 R14	**Yokohama E400** 195/60 R15	**Goodyear** 205/60 R16	**Continental TL** 265/65 R17
Apollo 155/70 R12	**Bridgestone** 165/65 R13	**JK Tyres Tornado TL** 165/80 R14	**Bridgestone** 175/60 R15	**Apollo** 255/65 R16	**Good Year** 215/55 R17
MRF ZLX R 145/80 R12	**JK Tyres** 185/70 R13	**MRF ZLO** 185/70 R14	**Continental AT** 255/70 R15	**Falken Azenis** 205/60 R16	**Pirelli** 235/65 R17
	Michelin 145/80 R13	**Apollo Amazer 4G Life TL** 155/65 R14	**Apollo AXL/TT** 165/80 R15	**Bridgestone** 215/65 R16	**Bridgestone TL** 235/65 R17
	Torque 155/80 R13	**Goodyear Duraplus** 165/80 R14	**Michelin Energy XM2 TL** 205/65 R15	**CEAT** 195/55 R16	
	Torque 165/65 R13	**Sunfull** 165/80 R14	**Sunfull** 195/60 R15		

The test agencies including IRMRA and ICAT have played an indispensable role in the entire exercise by not only conducting RR and wet grip testing as per the international protocols but also supported the team in thoroughly examining the test protocols.

Testing of tyre samples for RR

The overall plan for the testing of tyre samples for RR involved procurement of tyre samples from **authorised dealers** in the open market and delivery of these samples to IRMRA's premises for testing. As IRMRA's testing facility is located in Thane, Maharashtra, the tyres were procured from authorised local dealers to avoid transportation time and costs.

The tyre samples, after being delivered to IRMRA, were segregated into six different lots of five tyres each. Tyres from one lot were tested at one go, and each lot was tested separately. **The test procedure followed was as per ISO 28580**, and the results of testing were delivered lot wise. The project team witnessed the testing of 'lot 1' first hand.[12]

Testing of tyre samples for wet grip index

NATRAX's premises in Indore were selected as the site to perform wet grip testing. The testing of passenger car tyres for determination of wet grip index 'G' was done as per the procedure mentioned in UNECE R117.02 (and its amendments). The testing was performed by M/s ICAT as per the procedures defined in UNECE R117.02 and its amendments. The facility of M/s ICAT for wet grip testing is the only and first such facility commissioned in India in a third-party laboratory.

The results of RR and wet grip testing of the tyre sample set were delivered to the project team. The relationships exhibited by RRC and wet grip with other key tyre parameters are explored in the following chapter. The chapter also comprises key insights crucial for conducting the benchmarking exercise and standard setting.

[12] The RRC results reported by IRMRA are not aligned with the Network of Reference Laboratories in Europe. The aligned RRC results will be reported once the correlation equation for the machine in IRMRA is established.

Key findings

The test results were analysed using statistical analysis techniques, such as regression, to identify and understand relationships between several parameters such as RRC, wet grip index, rim diameter, section width and aspect ratio. The statistical analysis presented in this chapter is only for illustrative description.

The RRC results (unaligned) for sample tyres are:

Tyre code	RRC	Tyre code	RRC	Tyre code	RRC
H1 - 12	13.52	B2 - 14	11.96	M2 - 15	11.36
F4 - 12	11.23	E2 - 14	11.89	A1 - 16	9.79
E3 - 12	12.25	F1 - 14	14.27	F3 - 16	10.61
E1 - 13	14.61	A2 - 14	13.18	L1 - 16	12.18
K1 - 13	12.59	M1 - 14	11.09	K3 - 16	10.16
B1 - 13	13.65	J1 - 15	10.09	H2 - 16	12.01
D1 - 13	11.61	K2 - 15	11.35	C1 - 17	8.22
G1 - 13	12.39	C2 - 15	12.49	A3 - 17	7.93
G2 - 13	11.17	F2 - 15	11.85	I2 - 17	9.08
I1 - 14	11.04	D2 - 15	8.77	K4 - 17	10.18

The wet grip index (G) results are:

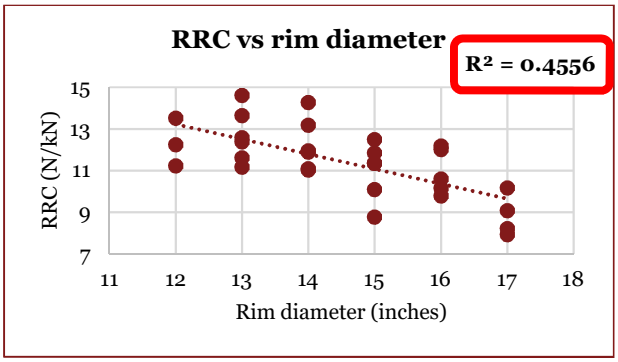
Tyre code	G	Tyre code	G
T1	1.00	T10	1.26
T2	1.10	T11	1.43
T3	1.20	T12	1.19
T4	1.20	T13	1.06
T5	1.27	T14	1.12
T6	1.22	T15	1.39
T7	1.13	T16	1.24
T8	1.24	T17	1.18
T9	1.25	T18	1.27

During the analysis, three major observations were made. These observations were extremely relevant to policymaking for tyre RR and wet grip:

- Relationship between RRC and rim diameter
- Relationship between wet grip index and rim diameter
- Relationship between RRC and wet grip index

Relationship between RRC and rim diameter

The results of the regression analysis between RRC and rim diameter are shown below. The analysis of variation (ANOVA) table is also provided.



	Coefficients	*Standard error*	*t Stat*	*P-value*
Intercept	21.800	2.157088	10.10634	7.62E-11
Rim diameter	**-0.714**	0.147594	-4.84047	4.29E-05

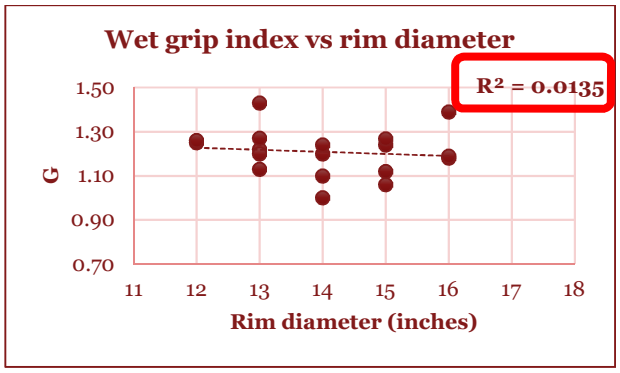
The results indicate that **RRC and rim diameter display a negatively sloped linear relationship**, which is statistically significant in nature (p-value of slope < 0.05 and R^2 = 0.4556). The value of the coefficient suggests that *on an average, for every one inch increase in rim diameter, there is a gross decrease of 0.714 N/kN in the value of RRC*. Consequently, the RRC values of tyres with rim diameters of 11" to 14" exhibit significantly higher values of RRC than those with rim diameters of 15" and above.

As a consequence of lower RRC values, tyres with larger rim sizes are more efficient. Also, it was observed that most of the samples in the latter comply with the EU stage 1 requirements of 12 N/kN. Incidentally, in the EU, most of the tyres sold have a rim diameters of 15" and above.

This indicates that tyres in India within the 15" and above segment already adhere to EU stage 1 RRC requirements.

However, tyres with rim diameters between 12" and 14" do not meet the EU stage 1 requirements. This may be due to their smaller sizes.

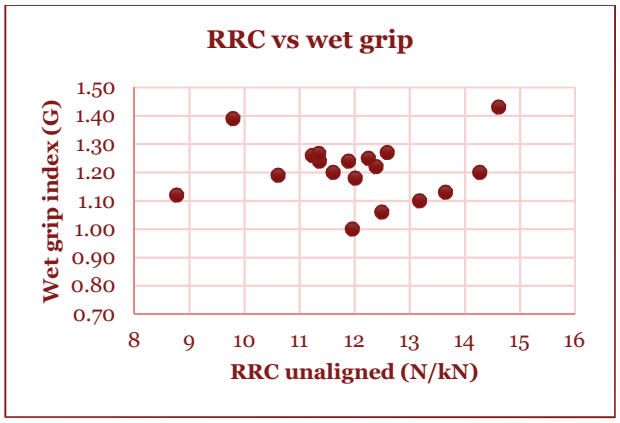
Relationship between wet grip index and rim diameter



	Coefficients	Standard Error	t Stat	P-value
Intercept	1.339784	0.282652	4.740041	0.00022
Rim diameter	-0.00936	0.02003	-0.46751	0. 64644

The above results and the graph indicate that **the wet grip index values of tyres do not depend on their rim sizes**. Also, significant variation in wet grip values is observed within each rim diameter segment.

Relationship between RRC and wet grip index



	Coefficients	Standard error	t Stat	P-value
Intercept	1.174559	0.219155	5.359497	6.39E-05
Rim diameter	0.00280	0.018138	0.154443	0.879192

Very little correlation between RRC and the wet grip index was observed based on the test results. This implies that there is a negligible relationship between RRC and wet grip index.

This indicates that consumers have the option of purchasing tyres with lower RRC values without compromising on wet grip performance.

This also indicates that a policy option such as fuel efficiency labelling can positively impact the Indian market.

Summary of key findings

The RRC and wet grip index test results have brought out crucial insights into the relationships exhibited by these parameters with each other and with other tyre parameters. These insights are extremely relevant for benchmarking and identifying appropriate policy options for moving forward with the fuel efficiency mandate.

The following major conclusions were made from the examination of the test results:

1. Since tyres of smaller rim sizes exhibit higher RRC values, the introduction of threshold values for RRC would have a higher impact on tyres of smaller rim sizes. Incidentally, the Indian passenger car tyre market is dominated by lower rim sizes contrary to the passenger car tyre market in the EU or other developed economies where the tyre sizes are generally higher. Therefore, a few options may need further investigation:

    - Should a threshold value which is different from the value defined in the EU programme be adopted in India, given different market conditions?

    - Should there be two threshold values for RRC—that is, one threshold value for tyre sizes from 12” to 14” and the other value for 15” and above?

    These options are further discussed in the next chapter.

2. The significant variation of RRC values within a rim diameter segment implies that at least few fuel-efficient tyre options are already available in the Indian market. There are few tyres which are even qualifying for stage 2 limits of the EU’s standard for RRC. Incidentally, tyres marketed as ‘fuel efficient’ in the Indian market exhibited lower values of RRC.

3. The value of a tyre's wet grip index does not vary with its rim diameter, its section width, its RRC or any other parameter. Also, most of the tyre samples complied with the threshold limit value of 1.10 defined in UNECE R117.02. Therefore, a single threshold value for wet grip index across all rim sizes is appropriate. The selection of a threshold value is discussed in the next chapter.
4. As there is very little correlation between RRC and wet grip index, consumers have the option of purchasing tyres with lower RRC values without compromising on wet grip performance. This indicates that a policy option such as fuel efficiency labelling can positively impact the Indian market.

Benchmarking

Prior to defining the benchmarking process for India, the benchmarking processes adopted by standard and labelling programmes in other countries such as the EU, Japan and South Korea were first studied.

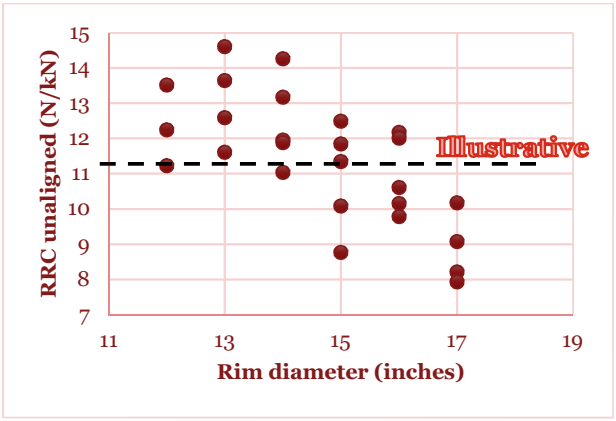
It was found that all of the above programmes are aligned with the limits specified in UNECE R-117, which sets the benchmark value for tyre RRC 12 N/kN in stage 1 and 10.5 N/kN in stage 2 for tyres of all rim diameters.

However, the approach may not be the most appropriate for India since the predominant size in the European market is 15" and above, whereas in India a majority of tyres range from 12" to 14". So, while the common benchmark value of 12 N/kN applies to tyres of all rim diameters in the EU, effectively the common benchmark impacts tyres beginning from rim diameter 15". In India, tyres of this rim size, as seen from the data, already have low RRC values and most qualify for this limit. However, tyres of rim diameters 12" to 14", given their lower sizes and consequently higher RRC values, may find it difficult to qualify for this benchmark.

This implies that if a common benchmark value for all tyre sizes is adopted in India, the requirements will be more stringent on tyres of lower rim diameters, which form the majority in India, than on higher rim diameters. To circumvent this issue, two more approaches for benchmarking, other than the common benchmark approach adopted in the EU, and are assessed on a case-wise basis. The three cases identified are described next.

Case 1: Common benchmark approach

Through the common benchmark approach, benchmarking of fuel efficiency performance of tyres is based solely on the unaligned[13] value of RRC of passenger car tyres, regardless of their rim diameters. The overall impact of the benchmark on the tyre market is depicted graphically in the following figure.



The resultant benchmark value will be common for tyres of all rim diameters. All tyres falling north of the benchmark exhibit a performance below that of the benchmark, and would fail to comply with a standard. The figure shows that with a common benchmark approach, tyres with smaller rims are more likely to fall below the benchmark value than those with larger rims.

Therefore, **standards based solely on RRC are likely to impact tyres of smaller rims more, which incidentally makes up majority of the Indian market**.

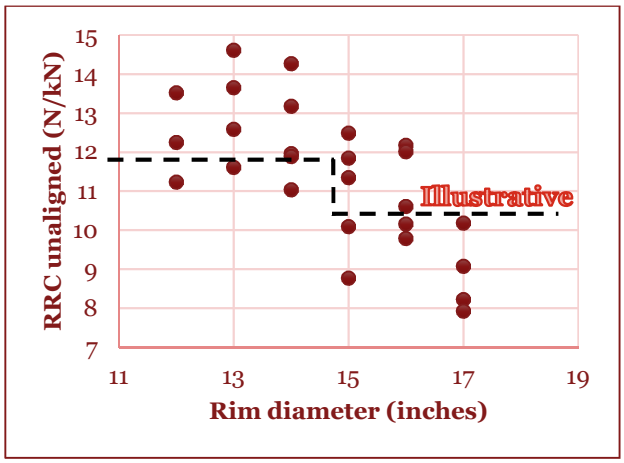
Case 2: Grouped benchmark approach

To circumvent the issue of higher impact on tyres with lower rim diameters in the common benchmark approach, separate benchmark RRC values are defined for tyres of lower rim diameters and tyres of higher rim diameters, hence the grouped benchmark approach. Under this approach, two groups are defined on the basis of the analysis discussed in the previous chapter and are shown below:

- Group 1 – tyres of lower rim diameters, i.e. 12" to 14"
- Group 2 – tyres of higher rim diameters, i.e. 15" and above

The overall impact of this approach on the tyre market is depicted graphically in the following figure.

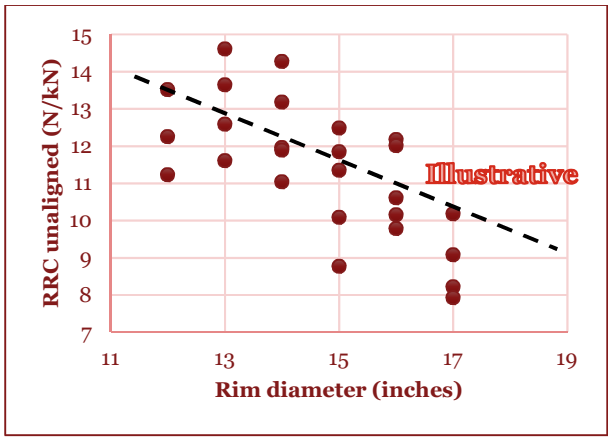
[13] RRC unaligned is the value of RRC obtained through the testing of tyres. These values have not been aligned with reference labs because IRMRA's lab alignment process is still underway.



All tyres falling above the benchmark line exhibit a performance below that of the benchmark and fail to comply with a standard. The figure shows that with the grouped benchmark approach, the overall impact of the benchmark is equally distributed between the two tyre groups.

Case 3: Benchmarking using a dummy variable

Another approach to circumvent the issue of higher impact on tyres with lower rim diameters in the common benchmark approach is described here. This approach is essentially an expansion of the grouped approach, but instead of defining different benchmark RRC values for different groups, benchmarks are defined on a dummy variable, which removes the net impact of rim diameter from RRC. The dummy variable is chosen such that the effect of the relationship between rim diameter and RRC is effectively neutralised. The overall impact of the benchmark on the tyre market is depicted graphically in the following figure.



All tyres falling northeast of the benchmark line exhibit a performance below that of the benchmark, and would fail to comply with a standard. The figure shows that with this approach, tyres of all rim sizes are equally impacted by the benchmark, unlike in the common benchmark approach.

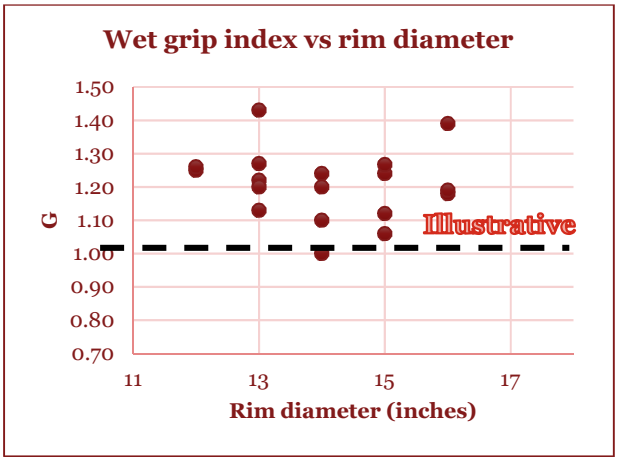
It is important to note that the dummy variable is simply used to determine where the benchmark lies and has no physical significance.

Assessment matrix for the three approaches

	Case 1	Case 2	Case 3
Approach	Common benchmarking approach	Grouped benchmarking approach	Benchmarking on the basis of dummy variable
Characteristics of benchmark	One benchmark for all tyres	Two separate benchmark values	One benchmark for all tyres
Benchmarking parameter	RRC unaligned	RRC unaligned	RRC vs rim diameter line
Stringency on low rim sizes	High	Distributed	Distributed
Stringency on high rim sizes	Low		
Fuel saving potential	High	Medium	Medium
Ease of implementation	Easy	Easy	Difficult

Approach for benchmarking of wet grip index

The approach for benchmarking of wet grip performance of tyres in the Indian market is more straightforward since the value of a tyre's wet grip index does not vary significantly with other parameters. A single threshold value across the entire market is most appropriate.



A threshold value will likely impact the market as shown in the following figure. All tyres lying below the threshold value (indicated using a black dashed line) will fall below the limit.

Proposed next actions

As discussed in the earlier section, several benchmarking and policy options are available for stakeholders to achieve an improvement in tyre RRC and, consequently, fuel efficiency. The underlying objective for policy development is '**minimising the value of RRC in tyres but without downgrading the overall wet grip/safety performance**'. To bring about this objective, three options were identified, as shown in the following table.

	Policy for RRC	Policy for wet grip
Option 1	MEPS and comparative labelling	Minimum threshold value and comparative labelling
Option 2	MEPS only	Minimum threshold value only
Option 3	MEPS and comparative labelling	Minimum threshold value only

*MEPS: Minimum Energy Performance Standard

Based on our understanding of the subject matter and past experience in tyre labelling, we believe that improvement in tyre RR and wet grip should go simultaneously, and therefore the policy option must be such that manufacturers are prohibited from downgrading wet grip performance in order to improve fuel efficiency.

Case for standard and labelling programme for passenger car tyres

The standard and labelling programme is one such policy which is globally accepted and has proved to be a cost-effective solution to drive fuel efficiency in the transport sector.

Given that fuel-efficient options are already available in the Indian passenger car market and wet grip index values are independent of RRC values, consumers have the option to upgrade to fuel-efficient tyres without compromising on the safety aspect. This implies that the sale of fuel-efficient tyres may increase if consumers are able to make a more informed choice during the purchase of tyres (in the replacement market). This presents a case of labelling of fuel efficiency of passenger car tyres.

To improve fuel efficiency, a comparative labelling programme for tyre RRC has been proposed. The tyre industry is already under pressure from OEMs to improve the fuel efficiency (and thereby reduce RRC) of their tyres, against the backdrop of fuel efficiency policies such as Corporate Average Fuel Efficiency (CAFE) norms and the upcoming passenger car S&L programme. The comparative labelling programme's objective for tyres will be to impact the replacement market where consumers have a choice to purchase fuel-efficient tyres. This will lead to a consumer-driven push for fuel efficiency and complement the ongoing fuel efficiency programmes in India.

However, it must also be ensured that a consumer-driven push for tyres with high fuel efficiency does not result in the introduction of tyres with poor wet grip performance in the future. This presents a case for a threshold limit value for wet grip index of passenger car tyres as a prequalification criteria.

For wet grip index, the limiting value proposed is such that most of the tyres within the sample set qualify and the value is also in-line with EU stage 1 requirements. This will facilitate the industry as a whole to introduce such tyres. Manufacturers and stakeholders then gradually work to develop technology in the next few years, during which the limit for wet grip should get more stringent.

Suggestions for the development of a standards and labelling programme for tyres

Amongst the key requirements for standards and labelling programmes for passenger car tyres, the information on the tyre market, reference standard/test procedure, infrastructure for testing and fuel efficiency performance data, is broadly in-place at present. The next steps shall be to develop the MEPS framework, considering the benchmarks decided between the stakeholders, and develop an M&E protocol. The data presented in this study can be the starting point for discussion between the stakeholders and, in parallel, the stakeholders can conduct more testing to expand the data set.

The infrastructure for carrying out RRC and wet grip testing needs to be expanded on a large scale to suit the programme requirements.